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(USDA PHOTO)

Fig. 1 An old Pinus bungeana at the Tan-chou-szu, near Peking. See Page 3.

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Arboretum Activities

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The December 1967 issue (Vol. 18, No. 4) of the *Bulletin* represents the last issue for which Dr. John M. Fogg, Jr. has assumed major editorship. Prior to his editorship the *Bulletin* appeared at infrequent intervals with the first issue (Vol. 1, No. 1) dating back to October 1935. Under Dr. Fogg's editorship, the *Bulletin* became firmly established as a quarterly publication recording the many phases of activity associated with a University Arboretum and Botanical Collection. All members of the Arboretum are certainly indebted to Dr. Fogg for his devoted attention to the *Bulletin* which is now distributed to some 1600 addresses including many botanical institutions and libraries throughout the world.

During the late months of Winter, Mr. Domenick De Marco and colleagues have continued their splendid work in maintaining and restoring various sections of the Arboretum. Worthy of special notice are the improvements in the Rose

(*Continued on page 14*)

The Lace-bark Pine, *Pinus bungeana*

Hui-Lin Li

The Lace-bark pine, *Pinus bungeana* Zuccarini, the Pai Sung (white pine) or Pai P'i Sung (white-bark pine) of China, is one of the most striking of ornamental trees. With its remarkable exfoliating bark exposing white patches, its massive trunk branching into several stems forming a wide crown, and stiff, evergreen, deep-green leaves more or less sparsely deployed on the branches, presenting an unusually decorative sight all year, it is highly esteemed by the Chinese and is now considered a most desirable ornamental tree all over the temperate world.

The Lace-bark pine is a unique tree not only horticulturally but also botanically. It is a species of the soft pine or white pine group, the subgenus *Haptoxylon* of the genus *Pinus* L. The soft pines are characterized by, among other things, their soft, little-resinous wood and deciduous leaf-sheaths, *P. bungeana* is the only three-needled pine in eastern Asia. In fact, this species together with *Pinus gerardiana* Wall, of the Himalayas are the only three-needled white pines and constitute the distinct section Gerardianae. *P. gerardiana,* however, is much less hardy and is scarcely known in cultivation. It resembles *P. bungeana* in branches and leaves and has a similar exfoliating bark, but the bark does not become white in old trees as it does in the latter. *P. bungeana* also differs in having brighter leaves, more quickly deciduous leaf-sheaths and much smaller cones.

Botanical Description

The tree grows to a height of 25-30 meters. The crown is pyramidal to rounded in outline, generally irregularly shaped. The taproot is straight and long, with few secondary roots. The trunk generally branches into several stems a short distance above ground. The bark exfoliates in large thin scale-like patches of irregular shapes. These scales become loose by winter and fall away the second year, leaving greenish to greenish-yellow or milky white areas changing eventually to chalky white in old trees (Figs. 1 & 2). The branches are long and slender, more or less twisted (Fig. 2). The young branchlets are grayish green, shiny, and glabrous. Buds are spindle-shaped, brown, about 1 cm. long, slightly or nonresinous, and formed of several reddish brown scales rough at the edge.

The leaves are three to a bundle, persisting four or five years, with basal sheath composed of numerous loose scales, deciduous entirely early in the first year. The leaves are stiff and dark green, sharply pointed and very minutely toothed along the margins. They are acutely keeled on the inner surface and marked with faint stomatic lines all around. There are four marginal resin canals on both the upper and lower sides.

The tree produces new cones about April. The staminate cones are arranged in loose spikes; they are about 6 mm. long. The pistillate cones are solitary or in pairs, shortly stout-stalked and subterminal, often becoming apparently lateral by the growth of a summer shoot. They are about 5-7 cm. long, ovoid in shape, broadest near the base, and obtuse-pointed at the tip. The larger ones attain a width of 3.5 to 4.5 cm. The cones are yellowish brown in color. The concave and thin scales have a broad keeled apophysis with a transverse ridge near the upper edge, with the narrow umbo forming a short broad spine reflexed at the tip. The seeds are 1 or 2 to each scale, broad ovoid in shape, light brown in color, and about 1 cm. long and 5-6 mm. wide and thick. They have short wings on all sides, deciduous when the seeds fall out of the cone (Fig. 3).

Growth Form

One of the distinctive features of the Lace-bark pine is its habit. Unlike most pines which develop a straight erect trunk, the trunk generally divides a few feet above ground into several stems. When young, these branching stems form a pyramidal crown which becomes more rounded in old trees. This many-branched form is a distinctive and desirable characteristic of the tree as an ornament.

Weatherall (cf. Dallimore 1934) notes that the tree "when not interfered with grows with a straight trunk, but the Chinese commonly wire the young tree so that instead of one trunk, it has several." This may not be a correct ob-

servation as the straight single trunk is an exceptional rather than a general condition with this tree. The trees in cultivation nearly always develop when young into a bushy habit rather than into tree form; botanical explorers who observed the tree in the wild all attested to the many-stemmed habit. This bushy habit seems to be a characteristic phenomenon of development in this species. Chou (1934) and Chen (1937) both note that upon germination the seedling grows in the first year, with its terminal bud, up to about one inch. The second and third years, besides the terminal bud, lateral buds begin to appear. In the fourth or fifth year the growth of the lateral buds become faster than that of the terminal bud. As a result, the trunk branches into several stems a few feet above the ground.

Fig. 2 Branch and foliage of Pinus bungeana at the Morris Arboretum.

Bark

The most striking feature of this tree is its interesting and highly ornamental bark. Quite distinctive from other pines, the tree sheds its bark in small flakes of irregular shape, revealing young green bark beneath. On older trees the exposed part of the bark on both the trunk and main branches becomes chalky white, while the bark of the younger branches remains yellowish or yellowish-green. It is generally observed that the white bark does not appear until the trees are 50 years old, thus the tree becomes more and more ornamental as it gains in age.

On a single tree the whitish patches, varying from greenish to yellowish to nearly pure white and appearing in all sorts of shapes, sizes and contours, are indeed a beautiful sight. This highly ornamental bark, together with the interesting twisted-branching form, decorated with fine green needled foliage through all the seasons of the year, make this tree one of the most highly cherished in China. The white bark is described as sparkling with light by one Chinese botanist (Chen 1937). In the words of a western botanist, the bark is dazzling whitish on the sunny side of the tree and greenish white on the shady side (Mayr 1906.). A more flowery praise of this tree is a verse composed by the Ming poet Chang Shu, some five hundred years ago. He described the "white pine" trees in front of a temple, when he viewed them through the rain and mist, as white dragons.

This whiteness of the bark appears only in the living condition. When branches die their bark turns blackish and these branches stand out conspicuously among the light colored ones. The whiteness is not due to a deposit but is the effect of reflection of light from microscopical cell structures. Upon the death of the branch the cells collapse and their walls thus do not reveal a whitish color.

Botanical Discovery

The tree was first named *Pinus bungeana* and described by Zuccarini and published by Endlicher in his *Synopsis Coniferum* p. 166, in 1847. Zuccarini based his species on specimens collected by the Russian botanist Alexander von Bunge in 1831 in the environs of Peking. Bunge was a naturalist with a mission sent by the Russian government to Peking in 1830 where he first met with this pine and many other plants not previously known to Europeans (Breitschneider 1898).

The exact collection on which this species is

Fig. 3 Staminate and pistillate cones. *Pinus bungeana* at the Morris Arboretum.

based was not cited by Endlicher, but Endlicher gives the name Kiu-lung-mu (Chiu-lung-mu) in Chinese characters. This name, meaning "nine-dragon tree," is actually not the Chinese name of the species as Endlicher believed, but the name bestowed by Emperor Chien-lung in the 18th century to a single tree. This famous tree with nine main stems is still extant, growing in the courtyard of the monastery Chieh-tan-szu in the west of Peking. We may safely presume this is the type specimen of the species. A picture of the large trunk of this tree is given by Dorsett (1931). Dorsett writes: "We were told while visiting this temple in the latter part of September, 1930, that this tree was planted about nine hundred years ago. It is low-branched and has nine main stems or trunks and is therefore known as 'the nine Dragon Pine.' The trunk below the branches and between two and three feet above the ground measures 228 inches in circumference, or something over six feet in diameter. The tree is spreading but we judge is not over fifty feet high," (Fig. 4).

Dorsett gives two other pictures. One is the next largest and next oldest, said to be over 700 years old, at the south entrance of the Winter Palace. A third, perhaps three or four hundred years, located in the yard of the monastery Tan-chou-szu, not too far away from the Chieh-tai-szu, is considered by him to have the whitest bark of any seen. He writes that "the specimen stood alone in the court with its deep green leaves, slightly reddish brown cones, which were opening and shedding their seeds, and its strikingly white bark, was a tree greatly to be admired," (Fig. 2).

Robert Fortune was the first one who introduced the species into cultivation in Europe in 1848. A few years earlier he observed the tree in cultivation in Shanghai and sent living specimens of young trees from there to England (Fortune 1857). Later in 1861 he observed old trees of this species in and around Peking. In his narrations of his experience in this ancient capital (Fortune 1863), he described the trees as grown there and depicted fairly correctly the tree in its typical habitat, the first illustration of this species.

A Frenchman, Simon, was sent by the French Ministry of Agriculture and Commerce to China

Fig. 4 The Nine-dragon pine at the Chieh-tai-szu, near Peking.

and Japan in 1860 to study the agricultural conditions. In 1862 he sent to Paris young plants of a beautiful pine called "pei go sung." He supposed it to be a native of the mountains towards Tibet and proposed the name *Pinus napoleoni* (Bretschneider 1898). This plant is the famous white-bark pine. The name given by Simon seems to have escaped the notice of all later authors. The only synonym of *P. bungeana* sometimes noted is the horticultural name given by Lindley and Gordon, *P. excorticata* Hort. ex Lindl. & Gord. in *Jour. Hort. Soc.* 5: 217. 1850.

Old Trees in China

In China more old trees are known to exist in and around Peking than in any other locality. Famous old specimens exist also in the Temple of Yen-tze (a disciple of Confucius) in Chu-fu, Shangtung province, in the Legislative Yuan compound in Nanking, as well as in Seoul, Korea (Chen 1937). However, as far as records go, the oldest and the most famous tree of all is the old tree at Mi-hsien, Honan province, not far from Sung Shan, the most central of the five sacred mountains of China. The tree has been famous since the Ming dynasty. In the work *Chun-fang-p'u* (Treatise of Plants) by Wang Hsiang-tsin, first published in 1621, a quotation from the *Gazetteer of Mi-hsien* tells about the Tien Shien Peh Sung (Fairy white pine) surrounded by stone tablets carrying inscriptions eulogizing the tree dedicated by famous and important persons through the generations. The same work quotes also from the *Yu-liang-chi* saying that "Three li (about 1/3 of a mile) east of Mi-hsien, in the courtyard of the Temple of the Heavenly Queen, there is a tree of White Pine. The trunk's girth measured the embracement of five persons. Three stems arise from the base, ascending to over 100 feet in height. The color resembles a powdered surface. Inside the powder there is a green surface. Upon scratching, resin exudes. The leaves resemble iron wire. The tree is gnarled and queer-looking, said to be several thousand years old."

It is uncertain whether this tree is still living. There seems to be no modern mention of it. The tree in Shantung mentioned above measures three feet in diameter, perhaps one of the largest trees extant.

The tree is, as mentioned above, especially commonly planted around Peking. The many beautiful old specimens, existing there present a most strikingly beautiful sight. To the present writer, such an impressive sight can still be vividly recalled after many years. Large specimens are especially numerous in the Western Hills, such as the Jade Spring Hill, Fa-yuan Monastery, Chin-yi Garden, and Sung Tang (the pine hall) (Chou 1934). Farther west in the hills near Men Tou Kou, about 60 *li* west of the city of Peking, in the courtyard of Chieh-tai Monastery, there is a huge specimen with nine main branches. This tree was specially bestowed with the name Chiu-lung-sung, nine dragon pine, by Emperor Chien-lung.

Although all the trees in and around Peking are apparently planted, Peking is situated within the natural range of species and it is quite possible that natural forests existed around Peking in former times. A small natural grove can be found on mountain tops near Jehol, northeast of Peking (Chou 1934). Thus the cultivation of the tree in Peking might have started locally.

Natural Range

For some time after the species was described botanically in 1847, only planted specimens were known; it was thus believed that the tree existed only in the cultivated state. Later however, wild stands of the tree were discovered by botanical explorers in a number of areas in various provinces in northern China. Its range extends from Szechuan and Kansu in the west to Shensi, Shansi, Honan, and Hopei provinces in the east. It is primarily a tree of the Yellow River valley. Only in western Hupeh does it occur south of the Yangtze River. In all these areas the tree is a comparatively rare one.

Sowerby (1937) summarizes all the records of occurrence of the tree in the wild known at this time. Records were also noted by Chou (1934) and Wu (1956). Maps showing its range have been presented by Critschfield and Little (1966) and Mirov (1967). Mirov's general outline apparently includes some cultivated records, while Critschfield and Little give the exact localities of natural stands reported in literature.

Sowerby is of the opinion that "the part of China occupied by Shansi, West and North Chihli (Hopei), Shensi, Honan and neighbouring parts of Hupeh and Szechuan may be considered as the true home of *P. Bungeana*, the province of Shansi, where it is most plentiful, probably being its place of origin."

Although the discovery of this tree in its natural habitat is considered a result of modern botanical explorations, record of the tree existing in the wild has actually been found in Chinese literature as early as the Ming dynasty five

or six hundred years ago. In the *Chun-fang-p'u,* there is a quotation from the Ming dynasty *Gazetter of Shang-chou* (now Shang-hsien, Shensi province) which says that the White Pine exists in the hills there in the thousands.

Common Names

The common English name as it appears in literature is Lace-bark pine. Earlier it was more generally called the White-bark pine, and Hance (1873), who used the name White-bark pine, was of the opinion that the name Lace-bark pine, "occasionally given to the species is inappropriate."

The Chinese at first called this tree Pai Sung (white pine). In later years the name Pai P'i Sung (white-bark pine) became more commonly used. In Peking (Peiping), it is also commonly called Pai Ko Sung (white-fruit pine), because the seeds are fragrant and edible (Chou 1934). There are a number of other vernacular names applied to this tree (Chou 1934, Chen 1937). The names Pai Kuo Sung (white-bone pine), Sha P'i Sung (snake-skin pine), and Huo P'i Sung (tiger-skin pine), all refer to the bark of the tree. The name Pan Lung Sung (twisted dragon pine), refers to both the sinuous branches and the colorful bark. It should be noted that the names Pai Sung and Pai Kuo Sung are sometimes also applied to the fir in northern China and Mongolia, *Abies nephrolepis* Trautv., and some of the records given under this name pertain to the latter species. However, descriptions of these plants and their geographical locations will often reveal their identity.

Cultivation

P. bungeana is a very strong hardy species. It is planted, as mentioned before, throughout many parts of northern China, especially in and around Peking. The climate of northern China is a very severe one, with very cold long winters, hot summers, and extended periods of extreme dryness.

According to Weatherall (cf. Dallimore 1934), who observed the trees in Peking: "The tree is exceedingly difficult to rear, and is usually bought under a guarantee that if it be not alive at the end of two years, the buyer gets his money back. Once these two years are passed the tree is very hearty though exceedingly slow in growth."

In and around Peking, Weatherall noted that the tree flourishes in thin rocky soil, where the rain can drain away quickly. It will stand 110° shade heat and 0° in winter and endure the bitter northeast gales of January and February of Peking.

The germination of the seed is very slow. It begins germination only 50-60 days after planting. In the first year it scarcely attains a height of one inch (Chen 1937).

Weatherall estimated that its life, as based on his observation in Peking, rarely exceeds 400 years. At about 250 years the tree is in its prime; afterwards gradual decay sets in.

The tree succeeds well in most European countries and in the northern part of the United States. Here at the Morris Arboretum the largest and oldest specimen, probably 60 years of age, has already shown considerable whiteness on the trunk and the main branches. Wright (1958) estimated its growth as about one foot a year. The tree branched very near the ground into five or six wide-spread main stems of unequal sizes. Unfortunately one of the larger stems was broken by a hurricane some time ago. The tree is still well-shaped, however, and with its bark becoming through the years closer to pure whiteness, this tree will become a sight of increasingly great aesthetic value.

Literature Cited

Bretschneider, E. History of European Botanical Discoveries in China. 2 vols. 1898.

Chen, Y. Illustrated Manual of Chinese Trees and Shrubs. 1937. (In Chinese).

Chou, H.F. The Familiar Trees of Hopei. 1934. (Chinese Edition).

Critschfield, W. B. and E. L. Little, Jr. Geographical distribution of the pines of the world. U.S.D.A. Misc. Publ. 991. 1966.

Dallimore, W. The lace-bark pine of China (*Pinus Bungeana* Zuccarini). Jour. Roy. Hort. Soc. 59: 249-250. 1934.

Dorsett, P. H. Glimpses of the white-barked pine in Peiping and vicinity. Nat. Hort. Mag. 10: 237-239. 1931.

Elwes, H. J. and A. Henry. The Trees of Great Britain and Ireland. Vol. V. 1910.

Endlicher, S. Synopsis Coniferum. 1847.

Fortune, R. Yedo and Peking. 1863.

Hance, H. F. *Pinus Bungeana*, Zucc. Jour. Bot. Brit. For. 11: 91. 1873.

Mayr, H. Fremländische Wald-und Parkbaüme für Europa. 1906.

Mirov, N. T. The Genus *Pinus*. 1967.

Smith, H. A preliminary report on botanical investigation in south and central Shansi. China Jour. Sci. & Arts. 3: 449-454, 503-509. 1926.

Sowerby, A. de C. The white-barked pine (*Pinus Bungeana* Zucc.) in north China. Jour. Roy. Hort. Soc. 62: 443-445. 1937.

Tang, T. Account of a botanical tour in Shansi. Bull. Fan Men. Inst. Biol. 2: 45-63. 1931.

Wilson, E. H. *Pinus Bungeana* Zucc. In Sargent, Planta Wilsonianae 2: 13-14. 1916.

Wu, C. L. The taxonomic revision and phytogeographical study of Chinese pines. Act. Phytotax. Sin. 5: 131-163. 1956.

On the Life and Greater Achievements of Sir Joseph Paxton at Chatsworth, Country Seat of the Dukes of Devonshire

Angus Paxton Heeps*

"Nowhere have I found so much to admire, nowhere so little to condemn, as at Chatsworth. Nowhere have I seen a place more favoured by nature, nor, at the same time more indebted to art. Nowhere have I beheld a place so thoroughly consistent as Chatsworth."

Thus wrote "Argus" in the *Gardeners Chronicle,* 1841. Such high praise was not common during England's "golden age" of gardening and such a statement must have been most gratifying to the man responsible for bringing to Chatsworth a reputation as one of the 19th Century's most outstanding gardens in all Europe. The man, Joseph Paxton, rose from very humble circumstances to become renowned as gardener, writer, engineer, and architect. It is unfortunate that an account of all his activities and achievements cannot be related in this short essay; this article can tell only of his early life and greater achievements at Chatsworth garden, Derbyshire, country seat of the Dukes of Devonshire.

Joseph Paxton was born on August 3, 1803. He was the seventh son of William and Anne Paxton, his father being a tenant farmer under the Duke of Bedford. Though little is known of Paxton's childhood, many of his statements in later life suggest that his early years were somewhat hard and unhappy.

At the age of 15 he started work at Battlesden, the seat of Sir Gregory Page-Turner, where he stayed for two years before moving to Woodhall gardens. Here Paxton learned much from his enthusiastic superior, William Griffin. Two years later he was again back at Battlesden but this time with a little more experience and a newly fired thirst for knowledge. When only 20 years old he was entrusted with the building of a large lake, which suggests that he had already gained the confidence of his employer. In 1823 Paxton was on the move once again, this time a little further afield. The London Horticultural Society (later to become the Royal Horticultural Society) had recently leased some land at Chiswick from the Duke of Devonshire, and established a garden there; the garden adjoined the grounds of Chiswick House, the Duke's favorite London residence. Paxton saw a chance to further his experience and lost no time in obtaining employment with the Horticultural Society at Chiswick.

It was not long before Paxton's personality and practical abilities began to emerge; after a short time he was promoted to foreman, and soon became known to the Duke of Devonshire who often wandered from the grounds of Chiswick House. The Duke writes in his Handbook of Chatsworth and Hardwick, "He was chiefly employed then in training the creepers, and newly introduced plants on the walls, through which he first excited my attention, and being in want of a gardener here (at Chatsworth) I asked Mr. Sabine who was then head of the establishment (at Chiswick), whether he thought that young man would do. He said 'Young and untried'." It appears that Mr. Sabine went on to give such a favorable account of Paxton that the Duke, at once, offered him the post of Head Gardener at Chatsworth.

To offer a young man of 23 a job as responsible as this was not unusual; it was unique. The Chatsworth garden was in a sadly neglected condition and needed a man of considerable experience and skill to restore it to its previous splendor. Just why the Duke offered such a position to so young a man, remains a mystery. It seems certain that Paxton, even at the age of 23 was an unusually talented and technically mature young man; the Duke probably thought that this new addition to his staff would bring fresh ideas to Chatsworth. However perspicacious a man the Duke of Devonshire may have been it is unlikely that he foresaw the effect that

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Fig. 1 Site of the Great Conservatory which was demolished in 1920. Only the foundation stones, etc. remain today.

this decision would have upon his own life and Chatsworth. His offer and Paxton's acceptance were to bring a lifelong friendship and understanding between the two men, a relationship between master and servant rarely paralleled throughout history.

Upon accepting this great challenge, Paxton set out for Derbyshire and Chatsworth at once. His own account of this journey and his arrival at Chatsworth gives us a glimpse of his humor and also shows unusual self-confidence for a man of his years. "I left London by Comet Coach for Chesterfield; and arrived at Chatsworth at half-past four o'clock in the morning of the ninth of May, 1826. As no person was to be seen at that early hour, I got over the greenhouse gate by the old covered way, explored the pleasure grounds and looked around the outside of the house. I then went down to the kitchen gardens, scaled the outside wall and saw the whole of the place, set the men to work there at six o'clock; then returned to Chatsworth and got Thomas Weldon to play me the water works and afterwards went to breakfast with poor dear Mrs. Gregory and her niece, the latter fell in love with me and I with her, and thus completed my first morning's work, at Chatsworth, before nine o'clock."

Upon his arrival Paxton could hardly have been impressed with the gardens. The Duke writes in his Handbook: "In the kitchen garden he found four pine houses bad; two vineries which contained eight bunches of grapes; two good peach houses and a few cucumber frames. There were no houses at all for plants, and there was nowhere a plant of later introduction than about the year 1800. There were eight Rhododendrons and not one Camellia."

Paxton quickly proved that he was worthy of his new appointment. By 1828 he had already improved some of the existing glasshouses, and in 1829 was given charge of the woods which he rescued "from a prospect of destruction."

In 1832 it was decided that the old greenhouse built in 1697 should be altered. The interior was completely remodelled and a glass roof put on, whilst the external features remained unchanged. The front walk was paved with stones 5½ ft. wide. Between each of the front windows was a semi-circular stone basin planted with trailing plants such as *Thunbergia alata*. These were trained upon trellis work on the front wall. A collection of stove ferns was also planted. The central division of the house contained a rock formation in front of which was formed a basin for aquatic plants. The back walk was elevated seven feet from the ground and was reached by a flight of steps; on the side next to the wall was an elevated border one foot wide which was devoted entirely to succulent plants. This house was heated by four fires and the hot air admitted between bars of wood of which the back walk was composed. Other plants grown in this house included *Hoya carnosa, Columnea hirsuta, Petraea volubilis, Clitoria ternatea,* and *Passiflora racemosa*. After the building of the Great Conservatory this house was converted back to a half-hardy house chiefly for the growth of Camellias, as such it can be seen today.

Paxton's interests were not confined to glasshouses alone; in 1830 he had moved a large weeping Ash despite the criticisms of others that such a large tree would stand little chance of survival. The Duke writes "Miraculous to have come so far, I was enchanted with it." The Ash still flourishes today.

In 1835 a site previously devoted to timber trees was cleared and an arboretum started. Paxton had been at work on the new pinetum since 1829, so this new venture was well within his capabilities. As the timber trees were removed they were replaced by many varied species of the finest trees. Much of the cost of labor and of the specimens themselves was covered by the sale of timber trees. At the end of the year 1835 there were already 75 orders comprising 1,670 species planted. When the operation was finally completed the 40 acres contained some 2,000 species. It is regrettable that many of these fine specimens have perished since that time, many of them in a great storm in 1960.

It should be noted that Paxton, of course, owed his fame and fortune to the Duke of Devonshire, a generous and most worthy man who sponsored so many of Paxton's ideas and innovations. Without his friendship and support, both moral and financial, Paxton might not have reached such heights of horticultural fame. The Duke did not keep the wonders of Chatsworth for his sole enjoyment but opened both the gardens and his house to the public. Loudon, a prolific writer and occasionally a harsh critic of Paxton writes in his Garden Magazine, "Chatsworth, open every day of the year, and shown to all persons, rich and poor without exception. The arboretum will be seen by thousands, who, perhaps, going there principally with the view of seeing the waterworks will come away not only with a remembrance of them but with the first germs of a taste for trees and shrubs, which they would probably never have possessed under other circumstances."

More common trees such as species of *Araucaria, Fagus, Quercus, Prunus, Laurus, Phillyrea, Virburnum, Acer, Malus, Betula,* and *Cunninghamia* were featured in the arboretum as well as many rare species. As in all his undertakings Paxton demanded and achieved perfection. He writes, "I shall keep a young man constantly examining the trees and shrubs in our arboretum, till I have removed everything from it that is not perfectly distinct, and rendered it in every respect as perfect as it can be made."

In 1836 Paxton decided that his previous work in glasshouse design and construction had furnished him with enough knowledge and experience to attempt a new and daring enterprise. He had already constructed a new range of wooden houses to his new designs as well as several other houses in the conventional style of that day. His conception, the Great Stove, was to be a glasshouse of immense proportions built on curvilinear lines. This form of architecture had never been thought possible for houses of large proportions. Surely no one had even entertained the thought that such a method of design could be applied to a house measuring 277 ft. long, 123 ft. wide and 67 ft. high. Despite criticisms, many of them from trained and much respected architects Paxton remained adamant. He insisted that such a house could be built on curvilinear lines to his specification. He had a fine consultant in Decimus Burton, who is credited by some as having designed the Palm house at Kew gardens; others credit this achievement to Richard Turner. Although such an argument is hardly relevant to this article, it is worth noting that the Palm House at Kew is one of the relatively few houses standing today of curvilinear form that bears resemblance to the Great Conservatory at Chatsworth.

In the building of the Great Conservatory, Paxton's ingenuity shone once again. He soon put to use the newly invented steam engine to make sash bars for the building and thus saved some £ 1200 in manual labor, a considerable sum in those days. The fitting of the glass presented yet another problem since he wanted panes 4 ft. in length. A Birmingham firm had recently introduced a new method of glass manufacture whereby it was possible to make a glass sheet 3 ft. long by 10 in. wide. Paxton wanted his glass 4 ft. long and saw no reason why they should not extend their limit by another foot. It says much for his tenacity and persuasiveness that he won the day. During the building of the Great Conservatory, which took four years, Paxton was called to accompany the Duke on a grand tour of Europe. He was away for seven months with the Duke from October 1838 until April 1839 but was kept well informed on the proceeding of the building operations by frequent letters from his wife.

The heating of this huge structure was a feat in itself. There were eight large boilers below ground level, heating enough water to fill seven miles of 4-inch diameter piping. The fuel was brought from some distance away by a long tunnel which ran beneath the cascade and part of the rockery right up to the Conservatory. The system was most efficient; Paxton writes in the Gardeners Chronicle, 1841: "I have much pleasure in adding that the heating of the Great Conservatory has been highly successful; for during the most intensely frosted night it was kept to 60°F with ease and without the aid of all the heating power which has never yet been necessary to recourse to."

The contents of this house included plants from all over the world and the Duke, in his handbook, gives a lengthy description of all the plants and their situations. The house was entered by the great door and Grand Central Carriageway, an avenue of orange trees; another avenue crossed at the center of the house, this a spectacular avenue of *Musa sapientum*. "Luxuriant and effective," writes the Duke. In one corner of the house a specimen of *Musa cavendishii* was planted, "a charming object with fruit, flowers, etc. in every stage of maturity and development." The ground level was divided into four borders, two on each side of the central carriageway, with smaller paths to allow access to the plants themselves. In the Northeast corner were some large rocks and amongst them some of the largest ferns; the rockwork continued along the east front right up to the water garden. Here were species of *Limnocharis, Nymphaea, Sagittaria, Hydrocleis,* and *Nelumbium*. Continuing along the house were *Lagerstroemia indica, Saccharum officinarum,* and a superb specimen of *Hibiscus rosa sinensis,* 10 ft. high and 24 ft. in circumference, forming a compact tree richly ornamented with scarlet blossoms.

The west front contained a grove of Mandarin Oranges, and at the Northwest end a fine plant of *Abutilon striatum,* 20 ft. in height could be seen with hundreds of bell shaped orange blossoms. Close by were specimens of *Datura* (Brugmansia) *suaveolens,* nearly 15 ft. in height, 40 ft. in circumference with several hundred flowers each 12 inches in length. The borders on either side of the central path contained innumerable plants; amongst them, the Dragon Tree (*Dracaena draco*) and huge specimens of *Strelitzia angustifolia,* in addition to the more common *Strelitzia reginae*. The gallery at the end of the house was reached by a flight of stone steps carried up through a pile of artificial rockwork over which various ferns, lichen, *Araceae,* and a number of epiphytes were profusely scattered. The gallery itself was 30 ft. above the ground presenting a magnificent view of the specimens below. A platform surrounded the entire area along the side wings for the arrangement of plants in pots, the Northeast end of which was occupied by a select collection of ferns.

The praise that the Great Conservatory received when all was planted and partially established must have surprised even Paxton. Even Loudon put aside his acid pen and paid tribute to the Duke and Paxton for this great achievement. Articles in every periodical of the day lauded this technical accomplishment; wrote one, "This magnificent structure may be regarded as one of the greatest modern works in gardening," (Fig. 1).

Not content with standing idle and basking in the cascade of compliments that poured upon him from all over Europe, Paxton decided that Chatsworth lacked a rock garden, and immediately went to work on the construction of one. The Duke notes in his diary, "In the autumn of 1842 there was not a single stone in these parts —you will now find a labyrinth of rocky walks; the Queen's Rock; Prince Albert's, and the Duke of Wellington's, the greatest of all. The spirit of some druid seems to animate Mr. Paxton in these bulky removals." Paxton's idea of a rock garden was very different from the average man's

conception of one. He argued that to copy a natural formation of rock it is necessary to display it in its true perspective and therefore, its true size. His rock garden shows plants to their greatest effect but only in limited number. Very little was written about the rock garden and its plantings, so it is difficult to imagine its true effect. The rocks can still be seen today towering up to 30 ft. in height. So skillfully were they erected that it is hard to believe that they *are* artificial in formation.

Having established himself as a gardener and architect of landscapes and buildings, Paxton commenced to display his talents as an engineer. He now suggested to the Duke that Chatsworth should increase its prestige still further by the erection of a fountain; a fountain to dwarf all others. In December of 1843 a survey was commenced "and all the different levels taken under the direction of Mr. Paxton, to whom the whole management of the works was committed." The fountain itself was to be in the canal pond on the south side of the house. However, it was first necessary to build a reservoir. This proved an immense undertaking as 100,000 cu. yd of soil had to be removed. When completed the reservoir covered an area of 8 acres and had an average depth of 7 ft. The fall from the Emperor Lake as the reservoir was named, to the canal pond was about 381 ft. over a distance of ½ mile. "I walked up with Paxton to see the new reservoir, half frightened by the immense work," notes the Duke. A pipe of 15 inch bore ran from the reservoir through the arboretum down through the "Walk of the Heroes" (a small avenue of statues, with a very beautiful background of a tall beech hedge) across the round lily pond and thence to the canal pond. In places it was necessary to cut a trench out of solid rock up to 15 ft. deep. The fountain reached a height of 280 ft. when the reservoir was quite full, some 100 ft. higher than its nearest rival at Hesse Cassel. To give some idea of the amount of water needed to keep this fountain at such a height, it is worth noting that in one hour enough water was carried to cover 1 acre 1 inch deep!

It must have been a great disappointment to both the Duke and Paxton when the Emperor of Russia, in whose honor the fountain had been named, sent word that we would be unable to visit Chatsworth. He was, however, greatly flattered by the gesture and had been much impressed by the reception Paxton had arranged for him at Chiswick. It was no doubt, a pleasant surprise for Paxton when the Emperor created him a Knight of Saint Vladimir and sent him a beautiful sable coat, and three silver gilt beakers.

Perhaps one of the most memorable of Joseph Paxton's achievements was his success in flowering the Victoria Lily *V. amazonica* for the first time (in England). The gardeners at Kew had failed to bring the plant into flower, and so seeds were dispatched to Chatsworth to see if, perhaps, their efforts would meet with success. The care and culture of the plant was entrusted to George Eyles, who was directly responsible to Paxton. So encouraging was the state of the plant by mid-October that Paxton wrote to the gardening press in order to keep the public well informed on its progress. The press took enormous interest in the project and really built up some tension by publishing all the letters received from Chatsworth both from Paxton and Eyles. "*Victoria* just coming into bloom and will probably open its flower in two or three days," writes Paxton. "First flower bud showed on 1st November, partly expanded by 8th November, finally expanded on the 9th. By the 10th November it was sinking under water." So great was the enthusiasm for this plant that even after its initial flowering, the press kept up a continuing story. On February 16th, 1850 Paxton again writes to the *Gardeners Chronicle,* "It will be gratifying to learn that two fine young seedling plants of the *Victoria* at Chatsworth have come up in the immediate neighborhood of the parent plant which is still flowering—doing well." So long did the *Victoria* episode last that one begins to find it difficult to believe that it is really a plant under discussion. In September 1850 some 13 months after the seed was first sown, its state of health is still of national interest, "The original plant of *Victoria regia* (*V. amazonica*) has now produced its 140th leaf and 112th flower bud." By this time, of course, Paxton, quite enthralled with this prodigy, had designed a house especially for it. In its new environment the Lily excelled and a new rage commenced, "the present one (*Victoria*) at Chatsworth is bidding fair to outgrow all Victorias grown in size and beauty."

It was certainly an outstanding plant; its leaves averaged between 6 ft. and 7 ft. across and were of such strength that Paxton even stood one of his children upon one to prove the point. Many, many thousands of words were written about the Lily, its culture, and its progress over a number of years. It is unfortunate that the discussion and debate this plant caused cannot be

fully told here. Some very fine specimens of this plant are to be seen at Longwood Gardens today.

An essay of such short length cannot do justice to its title, therefore an attempt has been made to give a descriptive but not a detailed account of Paxton's greater achievements at Chatsworth. It was his work and experiments such as the building of the Great Conservatory which led him to the heights of fame and the zenith of his career, namely his design of the Crystal Palace for the Great Exhibition of 1851, which earned him a knighthood from Queen Victoria. He was in fact, the first man ever to be knighted for his services to horticulture.

Chatsworth today, though still a fine garden, has lost its one time grandeur; no longer can it be afforded to employ one hundred and thirty gardeners in any stately home. It is a sad fact that of Paxton's greatest works, few material ones remain to bear memorial to him. However, through his prolific pen this man has imparted his vast knowledge to us all. With the help and generosity of the Duke of Devonshire, ever at his shoulder, Paxton brought horticulture to the masses and stimulated the beginnings that have brought horticulture to the public eye and made it the respected and esteemed profession that it is today.

References

Chadwick, G. F. 1961. The works of Sir Joseph Paxton, 1803-1865. London.

The Gardeners Chronicle. 1841-1846, 1849, 1850, 1852, 1855. London.

Index kewensis plantarum phanerogamarum. 1893-1966. Oxford.

Lindley, J. and Sir Joseph Paxton. 1853. Paxton's flower Garden. London. 3 Vols. Illus.

Loudon, J. C. (ed.). 1831-1842. Gardener's magazine. London. Vols. 7, 11, 15-18.

Markham, V. R. 1935. Paxton and the Bachelor Duke. London.

Paxton, J. 1835-1848. Paxton's magazine of botany and register of flowering plants. London. Vols. 2, 5, 6, 7, 9, 10, 11, 12, 14.

Royal Horticultural Society. 1956. Dictionary of Gardening. ed. 2. Oxford.

Thompson, F. 1949. A history of Chatsworth; being a supplement to the sixth Duke of Devonshire's handbook. London, New York.

Book Review

Plants, Man and Life. By Edgar Anderson. Berkeley, University of California Press, 1967. $6.00.

A botanical book, written some 16 years ago by an eminent botanist for the intelligent layman or the student designed to go into a career in botany, anthropology, geography, or related subjects, is fast becoming a classic. This is *Plants, Man and Life* by Edgar Anderson, first published in 1952. A reprinted edition, in cloth and paperback, is now available.

Dr. Anderson, of the Missouri Botanical Garden, is well known in the botanical world. He is one of the most active and productive botanists. He has published over 2000 scientific papers, notes, and popular articles. He has been President of the Botanical Society of America and the Society for Economic Botany.

It is fortunate for everyone interested in botany that Dr. Anderson is not an ivory-tower scholar but one who loves to associate with and inspires people. Besides being Professor at the Washington University, he teaches botany for the layman and conducts frequent tours for garden groups. He writes numerous popular articles on plants for the general public.

Most of Dr. Anderson's scientific work is on the genetics and ecology of plants, especially concerning cultivated crops. He seeks to define the intricate relationships of plants and man. This book is essentially an autobiography, telling of his studies, interests, and experiences in his elucidation of complex scientific problems.

Any one interested in botany, especially on the origins and evolution of the crop plants on which man's life and destiny depend, cannot fail to be interested in the contents of this book.

H. L. Li

American Magnolia Society

The first meeting of the recently organized American Magnolia Society was held in the Goldsmith Civic Garden Center in Memphis, Tenn., on March 9 and 10 with about 50 members and guests in attendance. Dr. Fogg, who was one of the founders of this Society, and has been its president since 1963, presided over the first day's sessions.

Saturday morning was devoted to a discussion of Magnolia species and hybrid relationships, present and potential hybrids in early blooming species, and propagation methods for Magnolia cultivars. Following luncheon there was a talk by Mr. Philip M. Savage on "What's Left in China" and a paper by Professor J. C. McDaniel entitled "What will we do with the Sweet Bay?"

In later afternoon a tour was made of several of the fine gardens of Memphis culminating in a cocktail party at the house of Mrs. W. L. Bangston.

After dinner, which was served at the Center, the members were treated to a showing of slides, chief among which was a fine set taken at the Strybing Arboretum by J. H. Brydon.

On Sunday morning the party inspected the extensive planting of Magnolias in the Arboretum and then returned to the Center for a showing of additional slides, general discussion, and the auctioning of a varied collection of select cultivars and seedlings.

The following officers were elected to serve for the coming year: President, J. C. McDaniel; Vice President, Walter S. Flory; Secretary-Treasurer, Philip M. Savage; Editor of the Newsletter, John M. Fogg, Jr.

Arboretum Activities

(*Continued from page 2*)

Garden, where a beautiful mosaic pool dating back to the Morris Family is now readily visible, the Bloomfield Farm area, the Swan Pond, and the several "Japanese Gardens" which in early days were a distinctive feature of the Morris Estate. The most urgent of major tree surgery and removal is now in progress and, as is true in any Arboretum, is merely part of a continuing long-term program.

Mr. Keyser is currently transplanting many trees and shrubs from the nursery section to permanent positions throughout the Arboretum. He is also growing an interesting seedling population of interspecific hybrids involving native deciduous azaleas derived from crosses which he made last Summer.

Many new acquisitions have been recently received at the Arboretum. We look forward with much interest to the maturation of new cultivars in such genera as: *Acer, Ardisia, Camellia, Cedrela, Eucalyttus, Lagerstroemia, Pyracantha, Quercus, Rhododendron, Rosa, Stewartia,* and *Viburnum.*

The donors of these materials include: the National Arboretum, Swarthmore Arboretum, Arnold Arboretum, Longwood Gardens, Conard and Pyle Co., Armstrong Nurseries, and others. Extensive collections of seeds are being received from Arboreta and Botanical Gardens throughout the world. To all of these individuals and institutions we are most indebted for these important additions of new genetic combinations to our collection.

In this issue of the *Bulletin,* I would call your especial attention to the unique contributions by Dr. Li and by Mr. Heeps. In discussing *Pinus bungeana* Zucc, Dr. Li records highly individual observations of the species in its native environment in China which will add interest to your viewing of this picturesque tree.

The essay on Sir Joseph Paxton represents a potential stepping-stone to a person and an era of astonishing versatility. The statements composed by Mr. Heeps have a special flavor since he happens to be a descendant of Sir Joseph. I am much indebted to Dr. George R. Potter, Visiting Lea Professor of Medieval History,

University of Pennsylvania, for reviewing the manuscript by Mr. Heeps. The article was of interest to Dr. Potter, since he serves as Archivist for the present Duke of Devonshire at Chatsworth.

The Staff

Dr. Fogg spent the Christmas recess in South America, traveling through Peru, Chile, Argentina, and Brazil. He visited many private and public gardens, took photographs of the native vegetation and collected specimens for the herbarium of the Arboretum.

On Tuesday, March 5, Dr. Fogg gave an illustrated lecture to the Germantown Horticultural Society on "Botanical Gardens of Ireland and the British Isles." From March 8 to 10 he represented the Arboretum at a meeting of the American Magnolia Society held in Memphis, Tennessee. Dr. Fogg was one of the founders and first president of this Society.

During the Spring Semester, he is giving Botany 500, Plant Geography, to a group of some 30 graduate and advanced undergraduate students.

A lecture entitled "Botany and Medicine" was given by Dr. Fogg to the Phi Beta Kappa Chapter of Ursinus College on March 14 and to the assembly of the Agnes Irwin School on March 27. On March 28 Dr. Fogg was the speaker at the monthly meeting of the Philadelphia Botanical Club; his topic was "A Botanist in South America."

Dr. Li is actively engaged in his research on the "Flora of Taiwan." Work is in progress also with Dr. J. J. Willaman on "Alkaloid Plants."

Dr. Patricia Allison is teaching Botany 410, General Mycology, during the Spring Semester to a group of 10 students majoring in Biology. She is also engaged in research on "Fungal Morphogenesis." Two of her graduate students are currently investigating spore germination and reproduction of an unusual Ecuadorean Basidiomycete. Dr. Allison delivered a lecture on "Strategy and tactics of pest control" at the Chestnut Hill Garden Club on 6 February 1968.

Dr. Dahl is supervising the research of a graduate student working on the pollen morphology of the Family *Buxaceae*. On 25 January 1968, he delivered an illustrated lecture on "Exotic plants in the North" at the Barnes Foundation.

Dr. Dahl attended the "Symposium on the Biosatellite II Experiments" sponsored by the National Academy of Sciences Space Science Board and the National Aeronautics and Space Administration in Washington, D. C. on 23-24 February 1968.

We are pleased to announce that two interesting species of plants will be available for local Associates of the Arboretum on the traditional "Plant Distribution Days" which this year will take place on Friday, May 24th, 9 A.M. until 4 P.M. and on Saturday, May 25th, 10 A.M. until noon. Identifying cards of instruction will be mailed by mid-May.

A. Orville Dahl

New Associates

The Arboretum is happy to welcome the following new Associates who have been enrolled since December 1967:

Mr. John G. Eddy
Mr. H. B. Frazer, Jr.
Mrs. Wm. B. Hargreaves
Mr. Joseph L. Hayden, Jr.
Mrs. C. W. Morris, Jr.
Mr. Sydney S. Morris
Mrs. Elizabeth B. Murphy
Mrs. Kenneth L. Swartz
Mrs. John W. Watson

MAP SHOWING ACCESS TO THE MORRIS ARBORETUM, PHILADELPHIA, PA.

Morris Arboretum Bulletin

JUNE, 1968

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Magnolia, hybrid cultivar 'Jane' (*M. liliflora* x *M. stellata*).

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THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Aboretum.

CLASSES OF MEMBERSHIP

Sustaining	$ 10.00 a year	Sponsoring	$100.00 a year
Supporting	$ 25.00 a year	Donor	$500.00

Arboretum Activities

It is a pleasure to announce the appointment of Mr. J. Angus Paxton Heeps as Superintendent of the Morris Arboretum. Mr. Heeps was born in Purley, Surrey, England and has had considerable experience with a wide variety of plant materials in English nursery and Park Department appointments. He is an honors graduate of Wisley (Royal Horticultural Society) and is a Fellow of that Society. Friends of the Arboretum will recall the interesting essay on Chatsworth which Mr. Heeps prepared for the previous issue of the *Bulletin*. Prior to his appointment with us, Mr. Heeps served as Manager of the Nursery Department of the W. Atlee Burpee Co.

Members of the Baxter Family, in the company of friends from the Germantown Horticultural Society, convened at the Arboretum on 27 April 1968 for the purpose of dedicating a beautiful bronze direction finder in the Baxter Memorial terrace in memory of the late Mrs. Samuel Newman Baxter.

(Continued on Page 30)

The Golden Larch, *Pseudolarix amabilis*

Hui-Lin Li

The Golden Larch, *Pseudolarix amabilis* (Nelson) Rehder is an unique deciduous conifer, originated from eastern China. It is a beautiful and valuable tree which is seldom seen in the gardens of this country. The leaves turn bright yellow in early autumn for a very brief duration before they fall. The delicate, bright green foliage in fascicles, displayed so regularly on the tips of the numerous short spurs on long branches that again regularly spread from the straight upright trunk, presents altogether a most ornamental and artistically pleasing sight. It is one of the most esteemed trees in the Orient, claimed by many to be, together with *Araucaria auracana* (Molina) K. Koch and *Cedrus deodara* (Roxb.) Loud. one of the three greatest ornamental trees of the world.

The Golden Larch is not a true larch, *Larix*. It resembles the latter in general appearance. They both have deciduous, soft, linear, flat leaves fascicled on dwarf spur branches and scattered singly along the young shoots. But its leaves are longer and broader than those of the larch and the spur branches are thicker and more club-shaped. In other features, *Pseudolarix* is quite different from *Larix*. The staminate flowers are solitary in *Larix* but clustered in *Pseudolarix*. In the pistillate cones of *Larix* the scales are persistent on the axis and the cones stay on the trees, while in *Pseudolarix*, the scales are deciduous, and thus the cones break up when mature.

The Golden Larch is also used as a timber tree in China. The wood is of good quality, easily worked, and the timber is used in construction. But as the tree is now becoming scarce in its natural range, its importance in this respect is very limited. It is now being cultivated in gardens around the world chiefly as an ornamental tree. Its value as a horticultural subject seems to deserve wider recognition.

Botanical Features

The tree can grow to a height of 30-45 meters with a girth of 1.5-2 meters. The main trunk is nearly always straight with long, spreading, horizontal and irregularly whorled main branching, forming a broad pyramidal crown. The bark is reddish-brown, fissured into narrow scales. The branchlets are of two kinds, long shoots and lateral dwarf spurs. The long branchlets are reddish-brown and glaucous; the spur branchlets are short and club-like, with a number of distinct annual rings, each bearing the cushion-like, pointed bases of a previous year's leaf cluster.

Fig. 1. *Pseudolarix amabilis*
1. Branch with pistillate cones and leaves.
2. Branch with staminate catkins and young leaves.
3. Staminate catkins.
4, 5, 6, 7. Stamens.
8. Cone-scale with small bract at base.
(From Beissner 1891).

The leaves are borne either spirally arranged and scattered toward the tip of the long branchlets or densely fascicled in a cluster of 15 to 30 at the end of the lateral spur branchlets. They are deciduous, linear, flat, about 3-7 cm. long and 2.5-3.5 mm. broad. These leaves are soft, feathery and light green, slightly rounded above and keeled beneath with a raised light green

mid-rib and two glaucous stomatal bands on both sides. In the autumn they turn bright yellow for a short period before falling off.

The tree is monoecious, with staminate and pistillate flowers on the same plant borne terminally on spur branchlets, appearing around April. The staminate flowers are in yellow, slender-stalked and drooping catkins, about 25-30 catkins in a cluster. Each catkin consists of about 20 anthers. The pistillate cones are solitary, short-stalked, pendulous and ovoid in shape, about 6.75 cm. long and 4-5 cm. across. They become more reddish-brown when ripe in the fall of the same year. Each cone is formed of numerous (sometimes up to as many as 50) ovate-lanceolate scales, cordate at base and emarginate at apex. The scales are woody. In the cone, they are very divergent and are deciduous, falling off readily when ripe. There is a small lanceolate and acuminate bract at the base of each scale on its outside which is about half as long as the scale and is keeled at the back. There are two seeds to each scale. These seeds are very resinous and are more or less irregularly oval in shape, with a soft membranaceous wing of whitish color. The wing is nearly as long as the scale (Figs. 1-3).

Fig. 2. *Pseudolarix amabilis* at the Morris Arboretum.

Discovery in China

The tree was long cultivated in China but was not known to the botanical world in the West until its discovery by Robert Fortune in the mid-19th century. Fortune, on a special collecting mission to China sent there by the Royal Horticultural Society of London in 1849, had first seen dwarf plants of this tree in pots in gardens around Shanghai. In the autumn of 1853, he found it growing in a wild state in the Tientai Mountains in Chekiang province, southwest of the coastal city Ningpo (Fortune 1856, 1857). He first noted it at the Tsan-tsin Monastery, at an altitude of 1,000 to 1,500 feet. A year later another grove of trees was found 20 miles westward, at the Quan-ting Monastery, along the highest part of the mountain ranges at about 4,000 feet altitude. The largest tree he observed, standing alone and clothed with branches near the ground, measured 130 feet in height and 8 feet in girth.

Fortune sent to England numerous consignments of seeds in 1853 and subsequent years. Only very few of these germinated. He sent to England at the same time a number of seedlings in Wardian cases and these were for some time the only trees growing in England.

Taxonomy and Nomenclature

In nearly all writings on *Pseudolarix,* the genus is considered monotypic, that is, with only a single species. However, Miss de Ferré (1944) of Toulouse proposed a second species, *P. pourteti* de Ferré, based on vegetative material only, as a segregation from the original concept of the monotypic genus. This action has not been followed by, or even noticed by, most other taxonomists. The Toulouse school of thought about Gymnosperms, however, continues to maintain that the genus comprises two species. In the recent, most extensive treatment on the gymnosperms, Gaussen (1966) re-emphasizes the differences between the two which he calls *P. kaempferi* (Lindl.) Gordon and *P. pourteti* de Ferré, respectively. The first is now considered by nearly all other taxonomists as a synonym of *P. amabilis* (Nelson) Rehder.

De Ferré & Gaussen attempt to justify their view on both morphological and geographical grounds. The main distinction is based on the size of leaves and certain anatomical features. The size of leaves is actually in any case somewhat variable and differs according to the season of the year and the age of the plant. Anatomical features are generally not reliable for taxonomic use in species-differentiation by themselves alone. Harrison (Dallimore & Jackson 1967) is of the opinion that de Ferré's species is only a juvenile form. This writer (Li 1968) has found that the geography of de Ferré is confused and often in error. Altogether there is no valid ground for differentiating the genus into two distinct species or even varieties.

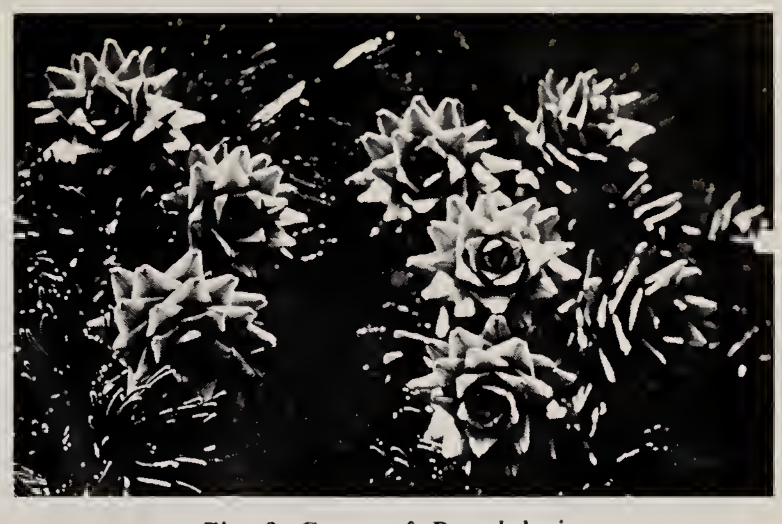

Fig. 3. Cones of *Pseudolarix*.

Another recent problem concerns the naming of this tree. Fortune first collected the plant in China and sent herbarium specimens back to England. Lindley in 1854 identified it as *Abies kaempferi* (Lambert) Lindley, a name he gave earlier to the Japanese Larch called *seosi* and named by Lambert as *Pinus kaempferi* Lambert. The latter is now known as *Larix leptolepis* (Sieb. & Zucc.) Gordon. Lindley's mistaken identification has since caused considerable confusion in nomenclature as well as in horticultural usage.

In 1858, when Gordon recognized the distinctiveness of the Chinese Golden Larch from the true larches, he established the genus *Pseudolarix* but retained the specific epithet *kaempferi*. Mayr, in 1890, realizing that this epithet was wrongly applied here, changed it to *Pseudolarix fortunei* Mayr. In the meantime, Nelson, who still considered the species as a larch, proposed the name *Larix amabilis* Nelson in 1866. As this specific epithet antedates the epithet *fortunei*, Rehder changed the name to *Pseudolarix amabilis* (Nelson) Rehder in 1919 and this is the name generally adopted since for the species. But the other invalid synonyms such as *P. kaempferi* and *P. fortunei* are sometimes still being used by some authors.

Recently, Moore (1965), believing that *Pseudolarix* as a name does not have a type, proposed the new generic name *Chrysolarix* and called the species *C. amabilis* (Nelson) Moore. However, Bullock and Hunt (1966) consider this action unjustified and that Moore's *Chrysolarix* is superfluous. The question centers basically on the technicality of typification. A species is typified by a nomenclatural type which is a specimen. The nomenclatural type of a genus, however, is a species and the latter is a concept and not a specimen. In the present case *Pseudolarix* is based on the Chinese Golden Larch clearly described and identified by Gordon, although the species at that time did not have a correct botanical name. Thus the argument seems more in favor of the view of Bullock and Hunt.

Early Records in China

The earliest records indicate that the Golden Larch was first cultivated in China in the T'ang Dynasty, in the 8th or 9th century. The quotation from the *Yo-yang Miscellany* of the ninth century, cited in detail below under "common names," shows that the plant was then common in the eastern part of Chekiang province, and especially abundant around Taichow. This is a city south of the Tientai Range. Li Teh-yu, a prime minister of T'ang composed a verse on the "Golden Pine" in which it is said that it originated in the Tientai Mountains. He also wrote a poetical essay on the tree, the preface of which says, " . . . south of Kuang-lin (modern Yanchow in Kiangsu province), there is an old mansion of Yen-tzu (a disciple of Confucius). When I visited one evening in late spring, suddenly I saw a strange tree planted in the courtyard. The branches resemble a pine and the leaves resemble those of the Chu-mai (pink, *Dianthus chinensis*). Looking at it more closely, the leaves are threaded in the middle with gold, shiny with light. When I inquired about its name, I was told it is called Chin Sung (golden pine). When I asked about its origin, it was said to have been obtained from the mountains of Taichow. I asked for a plant from the owner and planted it in my garden Ping-chuan (calm

spring) [in the capital Changan]. Now I have heard that the tree, being planted in a suitable location, has become very luxuriant in its branching and foliage. To record its origin, I am composing this poetical essay." Li Teh-yu was a garden enthusiast and produced also a work recording the plants growing in his Ping-chuan garden in the capital.

The Tientai Mountains and the Taichow area in Chekiang province seem to be the sites of the earliest origin of the cultivated trees. Natural forests must have been in great abundance even down to the Ming dynasty in about the 11th-14th centuries. The Ming *Gazetteer of Taichow* gives probably the most accurate description of the tree in its earlier records. It reads, "Taichow produces the Golden Pine. The hanging branchlets resemble those of the willow. Its cones resemble green balls. Every three years there is a ripened crop. The cones are produced every year and those of successive years are attached to the branches in different forms."

In the Ching Dynasty, around the 18th-19th centuries, the tree was becoming scarce, apparently because of excessive deforestation. The *Chi-Seng Chi-Shu* (*Provincial Gazetteer*) says that in Tientai Hsien (city located in the center of the Tientai Range and north of Taichow), "The Chin Sung (golden pine) has branches resembling the pine and leaves resembling those of the Chu-mai (pink, *Dianthus chinensis*). The tree is now scarcely met with."

It seems from the above that the earliest planted trees came from the Tientai Mountains in Chekiang province, the very same locality where Fortune discovered the tree in the nineteenth century. It grew in great abundance in this area in former times but when Fortune looked for the tree it had become much less common. That it is native to this area is beyond doubt and the suggestion made by some western authors that the tree may possibly be an introduction by Buddhist pilgrims from somewhere in western China is unfounded.

Natural Range

As mentioned above, the Golden Larch was first known to the botanical world by the collections made by Fortune in the mid-19th century in the Tientai Mountains in the eastern part of Chekiang province in eastern coastal China. This is also the region from which the first trees cultivated in the T'ang Dynasty over 1,000 years ago originated. Formerly extensive forests of this tree were reported in these mountains but now it is becoming scarce. Farther west and southwest in Chekiang province, in the Chuchi-Chinhua area, Ching (Price 1931) reported seeing large tracts of forest growths and believes this area to be the center of the natural range of the species.

The tree is also found in the southern part of Kiangsu and Anhwei provinces, in the north and south of Chekiang, in the southern part of Fukien province south of Chekiang, and in Kiangsi and Hunan provinces west of Chekiang. The range therefore covers a large part of eastern China south of the Yangtze River. This is the area of the original habitats of a number of relict plants. The most well-known is the Ginkgo. Other conifers and taxads include such relict endemic species as *Pseudotaxus* (*Nothotaxus) chienii* (Cheng) Cheng, *Torreya grandis* Fort., and *Torreya jackii* Chun (Li 1956).

In order to delineate the exact range of the species, a map is presented showing the exact locations on record (collector's name and collection number or year of collection), based on references to literature (Wilson 1915, Price 1931, Metcalf 1940). The place names (numbered) are being standardized (Fig. 4).

Kiangsu:	(1) SW Kiangsu, *Ching* in 1925.
Anhwei:	(2) Chiuhua Shan, *Ching 2637*.
	(3) Huang Shan, *Chien* in 1927, *Ching 3077*.
Chekiang:	(4) Tientai Shan, *Fortune* in 1853, in 1854, *Moule* in 1874.
	(5) Chuchi, (6) Chinhua, *Ching 1353, 1380*.
Kiangsi:	(7) Lushan, *David 882, 883, Maires* s.n., *Chung & Sun 400, Bailey* in 1918.
	(8) Kuikang, *David 910*.
Hunan:	(9) Hsinhua, *Handel-Mazzetti 571*.
Fukien:	(10) Lungyen, *Price,* photo only.

Common Names

The common English name Golden Larch is derived from the Chinese Ching Sung (Golden Pine). Nowadays, the tree is more commonly called in China, Chin Chien Sung (Golden-Coin Pine), apparently because of the fascicled leaves on the short branches resembling in their arrangement a coin (Chen 1937).

It is generally believed by both western and Chinese authors that the name "Golden Pine" refers to the fact that the leaves turn bright yellow in the autumn. Actually that does not seem to be the case in its original meaning. As mentioned above, the tree was first known in cultivation in the T'ang Dynasty, in the 8th or 9th century. In probably the earliest record of this tree, in the *Yo-Yang Tsa-Tsu* (*Yo-yang Miscellany*) by Tuan Ch'eng-shih, 863 A.D., it says, "Ching Sung (Golden Pine) has leaves resembling that of the Lily-Turf. In the middle of the leaves there is a line resembling a golden string. It grows in eastern Chekiang, and is especially abundant in Taichow." The golden line in the leaf refers evidently to the bright midrib inside the two glaucous bands of stomata, which is especially conspicuous on the undersurfaces of the leaves. Another record of the tree by Li Teh-yu, also of T'ang, quoted elsewhere, refers to the same golden line and the name "Golden- Pine." It seems that the name Golden Pine was originally based on this bright line in the pale green leaves rather than on the yellow leaves in the autumn. It is to be noted that the yellow fall coloration of the foliage is of very short duration, lasting only a few days. It does not seem appropriate to give a tree such a name which is applicable to only a very brief time of the year.

Fig. 4. Map showing the range of *Pseudolarix* in east China.

There is some confusion in the common names given by early western authors comparable to that in the scientific names. This stems from its misidentification with the Japanese Larch. Gordon, although he distinguished the Chinese tree from the Japanese Larch botanically, still followed Lindley's mistaken usage in saying, "The Chinese call this tree 'Kara-Mats' (Pine Full of Buds), and 'Kin-le-sung' (common Golden Pine): and the Japanese 'Fusi' or 'Fusji' (Buds Crowned with Leaves), and 'Seosa-mats' (Deciduous Fir)." The two Japanese names both refer to the Japanese Larch and not to the Golden Larch of China, and the first name attributed by Gordon to the Chinese "Kara-mats" is actually also a Japanese name and not of the Chinese, "mats" or "matsu" being Japanese meaning "pine." Only the second name is Chinese and it, Chin-le-sung, actually means "Golden Deciduous Pine."

The mistakenly applied common names of this tree of Gordon and other early authors are often repeated by later authors. To set the record straight, the following names are enumerated and the less common names are given with their proper authorization.

Chin Sung (Golden Pine): oldest Chinese name since the T'ang Dynasty.
Chin Chien Sung (Golden Coin Pine): name in Chinese horticultural works in later times.
Shui Sung (Water Pine): a name used in Huchow, Chekiang province (Chen 1937).
Chin Ye Sung (Golden-leaved Pine): a name used in Lushan, Kiangsi province (Wilson 1915).

Cultivation

The Golden Larch is not now widely and commonly cultivated. One of the reasons may be the confusion in its naming. It is not infrequently misidentified with the Japanese Larch in the trade. Another reason may be the usually sterile seeds. Dr. Anderson believes this is due to the fact that the trees growing in the Occident, aside from Fortune's original transplants, have been an inbred group.

Because of the relative rarity of the tree in cultivation our knowledge of its behavior and growth is rather limited. From the few records

of actual observations on trees growing in this country and in Europe, we are able to gather only some limited information.

The cultivation of *Pseudolarix* is generally considered to be difficult. The tree is slow-growing and it seems that it takes many years for the tree to establish itself before growth becomes measurable. However, in a favorable situation, such as that of the several old trees growing in the St. Louis area (Anderson 1966), growth of a foot a year is reported. Slavin (1967) records the growth of three trees obtained from Veitch Nurseries in England in 1905. In 1932 these trees were 25-32 feet in height, thus averaging around one foot per year.

The tree is quite hardy and in the United States it can grow as far north as southern New England. It grows better in eastern North America than in England, as the tree thrives well in this climate and it delights in hot summers. Sargent (Elwes & Henry 1912, Anonymous 1917) reports a number of large specimens and states that he never saw a plant which appeared to suffer from heat or cold, fungoid diseases, or the attack of insects. Anderson (1966), however, notes that in St. Louis, needle blight, as with a number of other conifers, had been a serious problem.

The tree is known to be difficult to raise from seed. Fortune (1860) states that for all the seeds he successively sent to England from China in 1853-55, only one batch out of many packages ever germinated. Others have experienced similar difficulties in raising trees from seed, yet seedlings frequently appear in large numbers under certain trees spontaneously. Fortune and others attribute this to the shade preferred by the seedling.

Elwes & Henry (1912), in recording the tree growing in Rovelli's nursery at Pallanza, Italy, a tree then claimed to be the finest specimen in Europe, report their observation: "Large numbers of natural seedlings appeared in prepared soil under the tree; and the seed is said to germinate better where it falls, than when collected and sown in pans under glass." They are of the opinion, "as the seeds and scales fall together and close to the parent tree, young seedlings probably succeed best with considerable shade."

That the seeds often grow better under or near the parent trees and not in the greenhouse may indicate that possibly there is an association of mycorrhiza with the trees.

According to Slavin (1967) the tree can be successfully grafted onto the larch. The remarkable tree growing in Ireland, named 'Annesleyana' by Hornibrook, is reported to be twice naturally layered (Chittenden 1932). The same phenomenon has not been reported elsewhere.

It is the general belief that the tree dislikes limestone soil. This was noted by various British authors (Elwes & Henry 1912), and Rehder (1940) cryptically notes this fact in his *Manual*. This view, however, has been challenged in this country. Slavin (1967) is of the opinion that the trees appear to do well in any light loamy, well-drained soil. He reports that the trees growing on limestones in Rochester, N. Y., are quite vigorous and hardy. Anderson (1966) reports trees in the St. Louis area growing and seeding themselves above limestone on a hillside where the soil is not deep.

At the Morris Arboretum, trees planted on the main ground where the soil is acidic grow far better than those planted in the nursery area, which is of limestone formation. In the latter area young trees often do not survive after a few years.

Based on its original habitat and the records of its cultivation, it is obvious that the tree does best on hillsides, and that they prefer good drainage. However, Anderson (1960) reports young trees of Golden Larch growing vigorously in a nursery bed with soil so water-logged that two young oaks were killed. The oldest and largest specimen at the Morris Arboretum is planted in a low, flat and damp area not far from a creek. It is in perfect condition. One of the Chinese colloquial names is "Water Pine." One wonders whether a moist situation is also a natural habitat of this species.

Horticultural Variations

The Golden Larch, in spite of de Ferré's attempt to distinguish two species, is a remarkably uniform species in its natural habitat. As a cultivated plant, no varieties are mentioned in Rehder's *Manual* (Rehder 1940). In many other works, three varieties are frequently mentioned. For instance, Chen (1937) and Krüssman (1960) both give the following three varieties here given with their characterizations:

1. 'Nana'
   A tree 1/3 to 1 meters high, bushy. Frequently cultivated in pots.

2. 'Dawsonii'
   A bushy shrub about 1/3 meters high. The crown is broadly pyramidal. Growth is very slow; used for pot planting.

3. 'Annesleyana'
   A bushy shrub to 2.5 meters high. Densely branched. The main branches are horizontal and the small branches descending.

However, this is somewhat misleading. These so-called cultivars do not actually exist in general cultivation as they are known either from a single specimen or are just based on an imaginary plant.

Among these 'Dawsonii' and 'Annesleyana' were first recognized by Hornibrook (1938) as varieties. The name 'Annesleyana' was given to the tree mentioned above, as growing in Castelwellan, Co. Down, Ireland, with spreading self-layering lower branches. 'Dawsonii' refers also to a single specimen, a dwarf one growing at the Arnold Arboretum in a pot. 'Nana' was proposed by Beissner (1891) who refers this variety to the dwarf potted plants seen and reported by Fortune in China in 1840. However, these potted plants may be artificially dwarfed trees raised from seedlings or young plants. There is no evidence to indicate that these plants actually represent a genetically dwarf variety.

Nielson (1961) described a type of cone from a cultivated tree in Denmark planted in 1890. It bore cones for the first time in 1958 and again in 1960. These cones differ from the cones generally pictured in being smaller, having fewer well-developed scales, and rudimentary ones towards the end of the axis of the cones. This condition is not noted in any of the herbarium collections made from the original habitat in China. It seems to indicate not a genetic variation but a case of malformation probably due to the local prevailing climatic conditions during the formation of the cones.

Literature Cited

Anderson, E. The Golden Larch, *Pseudolarix amabilis*. Miss. Bot. Gard. Bull. 54 (2) : 3-11. 1966.

Anonymous. *Pseudolarix amabilis*. Bull. Pop. Inf. Arnold Arb. N.S. 5 : 57-60. 1919.

Beissner, L. Handbuch der Nadelholzkunde. 1891.

Chen, Y. Illustrated Manual of Chinese Trees and Shrubs. 1937. (In Chinese).

Chittenden, F. J. (ed). Conifers in Cultivation. 1932.

Dallimore, W. and B. Jackson. A Handbook of Coniferae and Ginkgoaceae. 4th Ed. Rev. by C. S. Harrison. 1967.

Elwes, H. J. & A. Henry. Trees of Great Britain & Ireland. Vol. 6. 1912.

Ferré Y. de. Une nouvelle espèce de *Pseudolarix: P. Pourteti*. Trav. Lab. For. Toulouse 1. 4. Art. 4: 1-9. 1944.

Fortune, R. Leaves from my Chinese note-book. No. 8—A journey in search of a new cedar or larch, called *Abies kaempferi*. Gard. Chron. 1855 : 242. 1855.

Fortune, R. A Residence among the Chinese from 1853-1856. 1857.

Gaussen, H. Les Gymnospermes, actuelles et fossiles. Fasc. 8. 1966.

Gordon, G. The Pinetum. 2nd Ed. 1875.

Hornibrook, M. Dwarf and Slow-growing Conifers. 2nd Ed. 1938.

Krüssmann, G. Die Nadelgeholze. 1960.

Li, H. L. A horticultural and botanical history of Ginkgo. Morris Arb. Bull. 7: 3-12. 1956.

Li, H. L. Notes on the taxonomy and nomenclature of *Pseudolarix*. Taiwania 13: —. 1968 (In press).

Melcalf, F. P. Flora of Fulkien and Floristic Notes on Southeastern China. 1st Fasc. 1942.

Moore, H. E. Jr. *Chrysolarix*, a new name for the Golden Larch. Baileya 13 : 132-134. 1965.

Nielsen, P. C. Guldlaerken, *Pseudolarix amabilis* (Nelson) Rehder. Dansk Dendr. Arssk. 5: 567-580. 1961.

Price, W. R. On the distribution of *Pseudolarix Fortunei*, the Golden Larch. Kew Bull. Misc. Inf. 2: 67-68. 1931.

Rehder, A. Manual of Cultivated Trees and Shrubs. 1940.

Slavin, A. D. Our deciduous conifers. Nat. Hort. Mag. 46: 108-122. 1967.

Wilson, E. H. *Pseudolarix*. In Sargent, Pl. Wilson. 2: 21-22. 1915.

The Barnes Lecture, 1968

On Thursday evening, April 18, the Sixth Laura L. Barnes Lecture on Botany and Horticulture was given in the Auditorium of the Penn Valley School. The speaker was Dr. William C. Steere, Director of the New York Botanical Garden and a member of the Advisory Board of Managers of the Morris Arboretum.

Dr. Steere's lecture, which was enjoyed by a gathering of about 300 persons, dealt with the "Plants of the Tundra." The speaker, who is one of the world's leading authorities on mosses, has spent many years studying the vegetation north of the arctic circle and with a series of beautiful color slides he showed his audience many of the plants characteristic of this bleak but botanically fascinating area.

Eight New Hybrid *Magnolia* Cultivars

T. R. Dudley and W. F. Kosar*

The U. S. National Arboretum announces the naming of eight new Magnolia cultivars of hybrid origin. All are F_1 triploid and sterile selections named in April 1965 by Mr. William F. Kosar, Horticulturist at the U. S. National Arboretum, Washington, D. C. They were selected from a set of progeny resulting from a 1955 and 1956 *Magnolia* breeding program at the National Arboretum. The new cultivars are superior to their parents in flower size, color, fragrance and profusion and exhibit unusual vigor and exceptionally good form. The original plants, which started to flower in the spring of 1962 in the National Arboretum *Magnolia* collection of these hybrid clones, are multiple stemmed, rounded or conical, 6-10 foot deciduous shrubs of erect growth habit (Fig. 1). The branching pattern and shrub outline of the new cultivars show little variability; however, the flower color and the number of tepals per flower may vary from year to year. The flower buds are borne upright and the flowers at maturity are mostly wide stellate-campanulate or cup-shaped, combining the *M. stellata* (Sieb. & Zucc.) Maxim. and *M. liliflora* Desrous. types. The tepals frequently are reflexed or twisted after anthesis.

All color designations are based on the Royal Horticultural Colour Chart, 1966. Herbarium specimens, photographs and slides of these new cultivars have been deposited in the Herbarium, U. S. National Arboretum. The cultivar names 'Betty,' 'Susan,' 'Pinkie,' 'Jane,' 'Ann,' 'Judy,' 'Randy' and 'Ricki' are registered with the *Magnolia* Registration authority in accordance with the *International Code of Nomenclature for Cultivated Plants,* 1961. No plants are currently available. Propagation material will be distributed by the National Arboretum to cooperating nurserymen, Botanic Gardens and Arboreta. Dr. Frank Santamour, Research Geneticist at the National Arboretum, is investigating the cytology of these cultivars and their parents. These data will be presented at a later date.

1. *Magnolia* 'Betty,' National Arboretum No. 28348, Plant Introduction No. 326574, resulted from the 1956 hybridization at the National Arboretum by W. F. Kosar of *M. liliflora* Desrous. 'Nigra' (Female, National Arboretum No. 2901) and *M. stellata* (Sieb. & Zucc.) Maxim. 'Rosea' (Male, National Arboretum No. 1415) (Fig. 2). This cultivar has exceptionally good large flowers with 12-19 tepals, and measures up to 8 inches in diameter at anthesis. At anthesis, the individual spatulate or lorate, or sometimes subulate, blunt or slightly apiculate tepals are 2-3 inches long, ¾ to 1½ inches wide and become lax above the middle at maturity. They are constricted below the middle into a more or less well defined claw that measures ¼ to ¾ of an inch wide. The flower buds are pointed, and sometimes apically curved, and principally 71A, red-purple; however, some fading occurs to 73D and 74D, red-purple, at the apex. Some tepals, especially the outermost, are 187A, greyed-purple. Upon expanding, the tepals are mostly 187D, greyed-purple, at the base, and grade into 73D and 74D, red-purple, toward the apex. At anthesis and afterwards, the outside surface of the tepals is 72A, red-purple, at the base, grading into 73D and 74D, red-purple, at the apex; the inside surface is 155D, white. The style lobes and 70-90 stamens, ½ an inch long, are 186B to 187C, greyed-purple. In Washington, it flowers in the third or fourth week of April.

2. *Magnolia* 'Susan,' National Arboretum No. 28350, Plant Introduction No. 326575, is a selection from the same cross that produced 'Betty.' In Washington, it flowers in the third or fourth week of April. The fragrant flowers with 6 uniformly, deeply colored tepals, are 4-6 inches in diameter at anthesis. The erect, mostly subulate to clavate, obtuse tepals are 2½-3 inches long and ½ to 1 inch wide above the middle. The tepals are gradually attenuated into weakly developed claws, and frequently the apical margins are unfolded. The flower buds are erect and straight, and primarily 71A and 72A, red-purple, occasionally grading into 71B, red-purple, at the apex. As the flowers open, the outer side of

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Figure 1. *Magnolia,* cv. 'Ann', N.A. 28344, illustrating many-stemmed habit.

the tepals is 71A and B and 72A, red-purple, at the base and grades into 70B, 72B and 74C, red-purple, towards the apex. At this stage, the inner surface of the tepals is uniformly 74D, red-purple. However, in the inner surface some of the inner whorl of the tepals is much paler at 69A and B, red-purple. At anthesis and afterwards, the outer tepal surfaces of the tousled flowers may be 70A, 72A and B or 73C, red-purple, grading towards the apex to 70C and D, 73D and 74C and D, red-purple. The inner side is more or less uniformly 74D, red-purple. The style lobes and 60-70, 1/3 to ½ inch long stamens are 187D, greyed-purple or occasionally 71A, red-purple.

3. *Magnolia* 'Pinkie,' National Arboretum No. 28351, Plant Introduction No. 326577, is one of the latest flowering cultivars among those listed. It comes into full flower in Washington one to two weeks after the others, and also has the palest flowers. It is the result of a 1956 hybridization by W. F. Kosar at the National Arboretum of *M. liliflora* Desrous. 'Reflorescens'[1] (Female, National Arboretum No. 2123) and *M. stellata* (Sieb. & Zucc.) Maxim. 'Rosea' (Male, National Arboretum No. 1415). "Pinkie" is distinguished by having cup-shaped flowers, 5-7 inches in diameter at anthesis, with 9-12 broadly obovate to spatulate and rounded or slightly apiculate tepals. The flower buds are blunt and stout, and are uniformly 70A, red-purple at the base, grading into 70D, red-purple, along the margins and towards the apex. Some flowers, especially the earlier ones, are darker, 71A, red-purple, at the base, grading into 74C, red-purple, along the tepal margins to the apex. The inside surfaces are white, 155D. At anthesis and afterwards, the tepals range from 73A, red-purple, at the base to 74D, red-purple, along the margins to almost white at the apex. The style lobes and 50-60, ½ to ¾ of an inch long stamens are 71B, red-purple.

4. *Magnolia* 'Jane,' National Arboretum No. 28349, Plant Introduction No. 326576, is one of the latest flowering of all these selections and is in flower in Washington the first and second weeks of May (Fig. 3). It is the product of a cross made in 1956 by W. F. Kosar at the National Arboretum using *M. liliflora* Desrous. 'Reflorescens,' National Arobretum No. 2123 as the female parent, and *M. stellata* (Sieb. & Zucc.) Maxim, 'Waterlily,' National Arboretum No. 1413 as the male parent. 'Jane' is distinguished by beautifully shaped, very fragrant, cup-shaped flowers having 8-10 symmetrical, broadly, obovate to spatulate tepals. At anthesis, the flower measures 3½ to 4 inches in diameter, and the tepals are 2 to 2½ inches long and ½ to 1 inch wide at the rounded and obtuse apices. The tepal margins are inclined to be infolded. The flower buds are erect, slender and are more or less uniformly 71A, red-purple, grading into 74C, red-purple, grading into 74D towards the apex. The inside surface color is 155D, white. At full anthesis and afterwards, the tepals are 78B, purple, and occasionally 73A, red-purple, at the base, grading into 73D and 74D, red-purple, or 75C and D, purple, towards the apex. The inside surface at this stage is white, 155D. The style lobes and 90-110 stamens, ¼ to ½ inch long, are 59B and C, red-purple, or occasionally 71B, red-purple.

[1]A distinctive clone with a name of uncertain validity.

5. *Magnolia* 'Ann,' National Arboretum No. 28344, Plant Introduction No. 326570, resulted from the hybridization in 1955 by Dr. Francis de Vos at the National Arboretum of

Figure 2. *Magnolia,* cv. 'Betty', N.A. 28348.

M. liliflora Desrous. 'Nigra' (Female, National Arboretum No. 2901) and *M. stellata* (Sieb. & Zucc.) Maxim. (Male, National Arboretum No. 1415), as did the cultivars 'Judy,' 'Randy,' and 'Rickie' (Fig. 4.) 'Ann,' is the earliest flowering cultivar in this series, commencing in the second or third week of April. It has erect and tapered flower buds that are 71A, red-purple, at the base, grading into the lighter 70B, red-purple, from the middle to the apex. Its flowers, at anthesis, are erect and measure 2 to 4 inches in diameter. The 6 to 8 broad, subulate or slightly obovate, acute tepals, measuring 2-2½ inches long and ½-¾ inch wide, are erect and not flared like those of 'Judy.' The cup-shaped pre-anthesis flowers have tepals that are 71B, red-purple, that fades into 75A, B, C and D, purple, along the margins towards the apex. At anthesis and afterwards, the tepals are 72B, red-purple, basally, grading into 74D, red-purple, apically and marginally. The 50-60, ¼-½ inch long stamens are 71A and B, red-purple, especially at the base. The inside of the tepals is 75D, purple.

6. *Magnolia* 'Judy,' National Arboretum No. 28345, Plant Introduction No. 326571, is distinguished as the slowest growing of this series of cultivars, and has an erect, almost fastigiate habit. It flowers in the third and fourth weeks of April in Washington, and has the smallest flowers, the three outer tepals of which are furrowed, while the inner ones are distinctly keeled and widely flaring. The flowers at anthesis have 10 subulate to spatulate, acute tepals, and measure 2-3 inches in diameter. The buds are erect, candle-like and pointed, and are 71A, red-purple, at the base, grading into 70A, red-purple, towards the apex. The inside of the tepals is creamy white, 155A. At anthesis, the tepals are 70B, red-purple, fading into 70C and D, red-purple, towards the apex. The style lobes and 40-50, ¼-½ inch stamens are 71A, red-purple.

7. *Magnolia* 'Randy,' National Arboretum No. 28346, Plant Introduction No. 326572, flowers in the fourth week of April in Washington, and is extremely floriferous and has an erect and ascending, almost columnar habit. Pre-anthesis flowers are generally cup-shaped, and the tepals overlap with each other at least ½ their width. At anthesis and afterwards, the flowers are 3½-5 inches in diameter with 9-11 tepals, and have a stellate appearance. The subulate to spatulate, obtuse or slightly apiculate tepals are 2 - 2¾ inches long, and ½-⅞ of an inch wide at the apex. Their apical margins are often infolded. The flower buds are erect, pointed and uniformly 71A, red-purple, grading into 72B, red-purple, above the middle and at the apex. At the base, the pre-anthesis tepals are 71B, or 74B and C, red-purple, and fade to 70A through D, red-purple, or 73A and B, red-purple, towards the apex. The inside tepal surface is 155D, white. At anthesis and afterwards, the tepals uniformly grade from 72A or 73A, red-purple, to 72D or 73D, red-purple, at the apex. The style lobes and the 50-70, ½ - ¾ inch stamens are variable in color from 59C, 71A to 74C, all red-purple.

8. *Magnolia* 'Ricki,' National Arboretum No. 28347, Plant Introduction No. 326573, begins to flower in Washington the fourth week of April, has a strict habit, and consistently has the largest flowers of the de Vos hybrid selections. The tousled flowers with 10-15 twisted and contorted tepals are 4-6 inches in diameter at anthesis. After anthesis, the tepals flare and are reflexed at the middle. The spatulate, obovate or subulate and acute tepals of irregular width are 2-3½ inches long, ½ to 1¼ inches wide and prior to anthesis are 71C or 61A through C, red-purple, at their bases, grading into 74C through D, red-purple, at the apex. The erect, long, slender and pointed flower buds are 71A, red-purple, basally and grade to 73A through C, red-purple, towards the apex. At anthesis and afterwards, the tepals are 74C, red-purple, or 61B, red-purple, at the base, fading to 75A through D, purple, or 74C and D, red-purple. The inside color of the tepals is not consistent; some tepals, especially the inner ones, may be white, 155D, while others, particularly the outer ones, may have an inside surface color from 71A, red-purple, to 75D, purple. The style lobes and 80-100, ¼-½ inch stamens are 71A, red-purple, or occasionally 187D, greyed-purple.

Figure 3. *Magnolia,* cv. 'Jane', N.A. 28349

Figure 4. *Magnolia,* cv. 'Ann.'

A *Magnolia* breeding, testing and evaluation project was initiated at the U. S. National Arboretum in 1955. Previous observations in the Washington, D. C. area disclosed that late spring frosts often damaged the floral display of the precocious oriental species such as *M. stellata* (Sieb. & Zucc.) Maxim., *M.* × *loebneri* Kache, *M. denudata* Desrous. and *M.* × *veitchii* Bean. On the other hand, *M. liliflora* Desrous., another oriental species, flowers 2-3 weeks later, and is seldom damaged. The first objective of the breeding program was to produce hybrids that would flower at least ten days later than the earliest flowering group, thereby minimizing the possibility of frost damage.

For the initial hybridization, pollen of *M. stellata* (Sieb. & Zucc.) Maxim. 'Rosea' was collected to be used to fertilize the later flowering *M. liliflora* Desrous. 'Nigra.' The only flowering male parent was chosen primarily for such characters as heavy flowering; compact, shrubby habit; many-tepaled, fragrant flowers; and mildew resistance. The late flowering female was chosen primarily for its red--purple flowers, and its hardiness. The hybrids selected are novel combinations of the characters of the parents. There is displayed a wide range of color, fragrance, number of tepals, and size of flowers. The named selections produce compact, heavy-flowering shrubs that are mildew resistant and as hardy as both parents. The primary objective was realized in that they flower later than the *M. stellata* parent. Subsequent hybridizations using other parental cultivars such as *M. liliflora* Desrous. 'Reflorescens' and *M. stellata* (Sieb. & Zucc.) Maxim. 'Waterlily,' produced similar and equally attractive progeny.

Arboretum Activities

(Continued from Page 18)

With the ultimate goal of issuing a catalogue of all woody species presently included in the Morris Arboretum, the Director has appointed two of our Graduate Students, Mr. K. Y. Lee and Mr. Ju-Ying Hsiao to the laborious but essential task of recording every woody specimen in the Arboretum. This is being done by making precise field notes which refer individually to each of the numbered grids on a detailed map of the Arboretum prepared in 1959 for such application. A summary of this type, when completed, should prove a very useful aid for a variety of purposes, including teaching and research.

While this is not intended to be a detailed account of the plant injuries of last winter, it has been evident that some individuals were severely affected. Fairly extensive winter-injury was evident in *Camellia sinensis* (L.) Ktze., × *Magnolia Thompsoniana* (Loud.) Sarg. and such heaths as *Erica cinerea* L. (a number of cultivars), and a few cultivars of *Calluna vulgaris* (L.) Hull, e.g. var. *minima.* With references to the heaths, undoubtedly some of such injury could be reduced by judicious use of protective materials such as spruce boughs and salt or marsh hay. Rather surprisingly the Mediterranean *Erica arborea* L. *alba* and the New Zealander, *"Hebe glaucophylla"* (*H. pinguifolia?*) survived reasonably well. The cultivar, 'Edith Bogue' of *Magnolia grandiflora* L. appears outstanding in the Morris Arboretum for its resistance to winter damage as well as for its excellent vegetative and flowering habits. Damaged varieties such as *Magnolia Thompsoniana* and *Camellia sinensis* are currently making rapid recovery. The apparent tenderness of *M. Thompsoniana,* with its elegantly lemon-scented blossoms, is both unfortunate and rather surprising since the parental species involved, *M. tripetala* L. and *M. virginiana* L., both possess considerable winter-hardiness. It would be of interest to repeat this cross using resistant individuals from the northern portions of their natural ranges.

Under quite difficult circumstances, several hundred examples of four taxa (*Rhododendron Schlippenbachii* Maxim., *Betula Maximowicziaana* Reg., *Fontanesia phillyreoides* Labill., and *Viburnum opulus* L.) were assembled for the Annual Plant Distribution days, 24 and 25 May 1968. With strengthening of our staff, and solution of related problems, I trust that improved plant materials can be made available for this purpose in the future.

The Staff

Dr. Hui-Lin Li received a Fulbright Award which enabled him to continue his long-term research on the Taiwan Flora in the Department of Botany at the National Taiwan University in Taipei, Taiwan during the period 1 May through 31 July, 1968.

At the annual spring meeting of the Faculty Research Club of the University of Pennsylvania on 17 May, Dr. Patricia Allison presented an illustrated lecture on " Fungi and Guided Missiles."

On six successive Wednesday evenings, beginning March 20, Dr. Fogg gave a course of lectures on "Botany for Gardeners" at the Pennsylvania Horticultural Society and on March 28 he addressed the regular monthly meeting of the Philadelphia Botanical Club on the subject of "A Botanist in South America."

On April 19 Dr. Fogg was the guest of Ralph Collier on his radio program from WFLN entitled Views and Reviews. This broadcast featured the forthcoming National Library Week and Dr. Fogg discussed his own book on Weeds. The following Friday, April 26, he spoke on the same subject at the Pennsylvania Horticultural Society as one of a series of lectures built around members of the Society who had written books on botany or horticulture. Dr. Fogg also participated in the 1968 Longwood Garden Seminar Series in connection with which he gave an illustrated lecture entitled "Plant Materials of Colonial American Gardens" on May 2.

From May 10 to 31 Dr. and Mrs. Fogg conducted a Garden Tour to Switzerland, Italy, Yugoslavia and Greece.

A small, informal social hour in recognition of Dr. Fogg's promotion to the status of *Professor Emeritus* took place on 3 June 1968. Dr. Fogg has held various University appointments with distinction for 46 years and if one would add his undergraduate days as a student, he has known the University of Pennsylvania for half a century! We extend best wishes to Dr. and Mrs. Fogg for an enjoyable future filled with the rewards of long service to the University.

Dr. Dahl attended the thought-provoking Symposium, "Challenge for Survival," which was presented by the New York Botanical Garden on April 25th and 26th. A long-term associate of the Arboretum, Dr. Ruth Patrick, contributed significantly to the Symposium with her splendid paper on the "Ecology of Freshwaters."

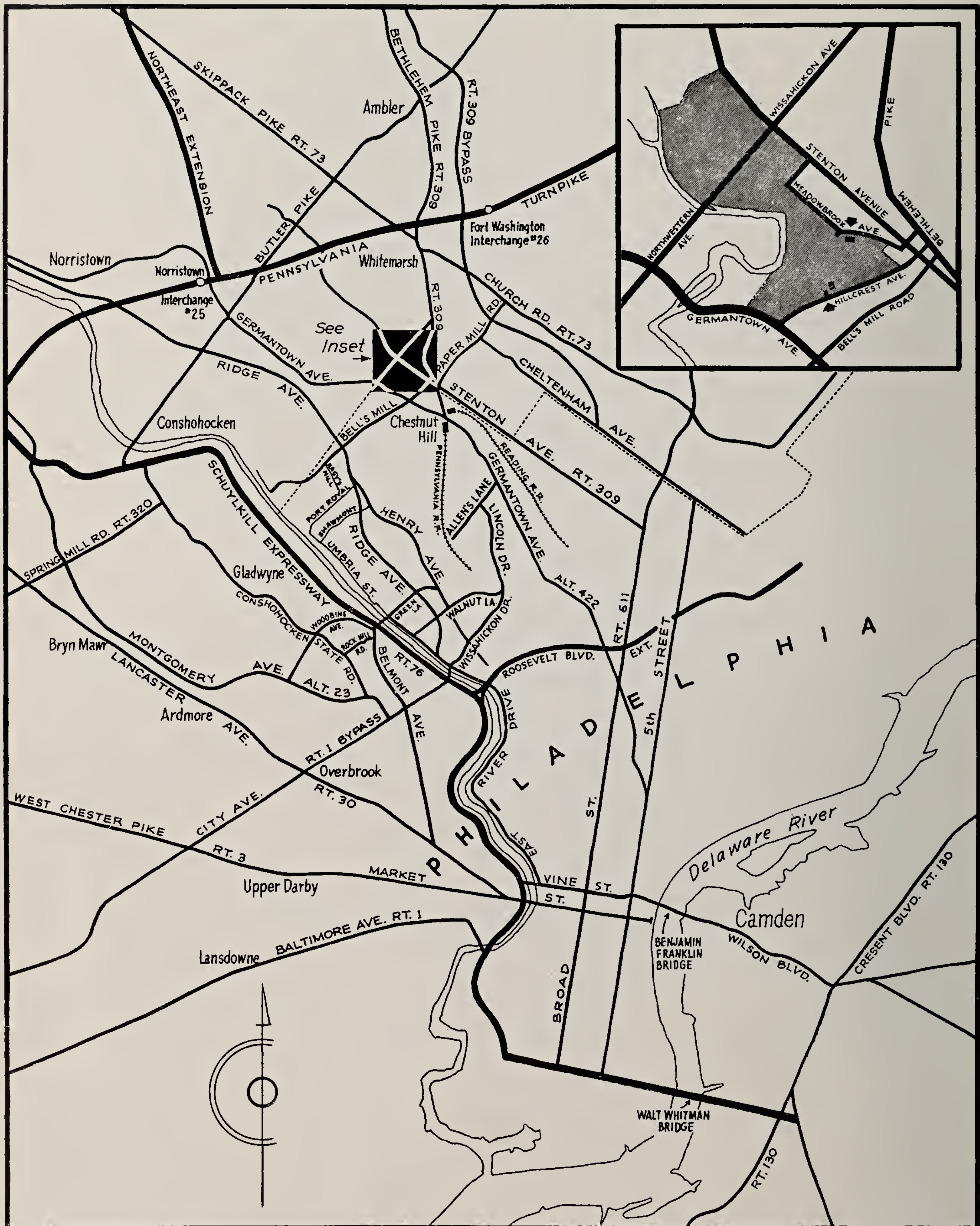
On 30th April, Dr. Dahl delivered a lecture on "Form, structure and development of pollen grains" at the Colloquium of the Department of Botany at the University of Wisconsin, Milwaukee. Later in the evening he presented a brief summary, in conjunction with a sound film, on his Biosatellite research relating to "Morphogenesis under conditions of weightlessness." During the period of 4-28 June Dr. Dahl, in collaboration with Dr. A. H. Brown of the Department of Biology, continued research on the Biosatellite project at the Ames Research Center, Moffet Field, California.

New Associates

The Arboretum is happy to welcome the following new Associates who have been enrolled since March 1968:

Mrs. Gertrude Amenth	Mrs. R. Barclay Knight
Prof. John Stuart Carnes	Mr. John A. McNichol
Mr. William H. Doe	Mrs. W. W. Meirs
Mr. & Mrs. Willis W. Kelly	Mr. & Mrs. Nicholas M. Walker

Mrs. John K. Willcox



MAP SHOWING ACCESS TO THE MORRIS ARBORETUM, PHILADELPHIA, PA.

Morris Arboretum Bulletin

LEGES SINE MORIBUS VANAE

SEPTEMBER 1968

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See Cover Photo Note, Page 47.

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THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Aboretum.

CLASSES OF MEMBERSHIP

Sustaining	$ 10.00 a year	Sponsoring	$100.00 a year
Supporting	$ 25.00 a year	Donor	$500.00

Arboretum Activities

This will announce a substantial revision in the arrangements for the publication of the *Bulletin*. Henceforth, the details of editing and preparation of materials will be the charge of an Editorial Committee made up of Dr. Hui-Lin Li, Dr. Patricia Allison, and Mr. J. Angus Paxton Heeps, with the Director as a member *ex officio*. Dr. Allison has graciously consented to serve as Editor.

Our aim will be the continuation of a publication presenting a combination of essays of general interest and a series of studies of more specialized, botanical and horticultural character. Such compromise is not always satisfying to everyone but we trust that the majority will sense the long-term value of including a representation of professional papers in various phases of botany. This was a hope expressed by Miss Lydia T. Morris in 1929 in her will, thus: "I desire that the Trustee maintain a laboratory in charge of scientific men, for the purpose of botanical

(Continued on Page 40)

The Beauty of Hardy Ivy[1]

by LÉONIE BELL, with drawings by the author

In a book of fascinating plant adventure and experiment, GARDENS IN WINTER (Harper, 1961), Elizabeth Lawrence revealed a longing that I share. "In winter I wish for an ivy garden," she wrote, "a little walled court where there is nothing but stone or brick and the ivy green." Yes. Only, instead of that little court I'd want linear yards of handsome masonry, perhaps in a labyrinthine arrangement something like that in Louise Beebe Wilder's last garden, "Balderbrae" in Westchester, New York.

For in our climate where the coldest days of winter *rarely* go below —5°F (and seldom that low here in Zone 6, where the recorded low is —10°), some ivies will survive in good condition on a north wall or the shaded side of a tree, a very few are still green in a southern exposure out of the way of drying wind, while many, if sheltered from sun beneath evergreen shrubbery, will reach April in pristine condition.

When you consider the assortment of vines hardy in our zone, very few are truly evergreen. By "evergreen" I mean *attractively* evergreen by spring. *Lonicera japonica halliana,* reputedly so, has leaves that hang down limply, that are brown by January, gone soon after. Another described as semi-evergreen is *Akebia quinata.* I have grown this for fifteen years — and tried to be rid of it for the last ten, longing that it be less hardy. It has proved to be completely deciduous.

But there are two really fine ones, Wintercreeper, *Euonymus fortunei,* and English Ivy, *Hedera helix.* Both have foliage variations, interestingly, but those of *H. helix* are so numerous, so decorative, that they more than make up for a dearth of species. Studying their foliage is a short course in the botany of leaf forms.

Most familiar is the 5-lobed botanical variety *helix* with its five prominent veins radiating from the base. The leaves can be 5 inches across in one cultivar, 1 inch in another, with several gradations between. Then the lobes can vary in depth, so shallow that there are actually none, or so deep that they resemble spiky bird tracks. Some are heart-shaped — broad hearts, slender hearts, ones with drawn-out points.

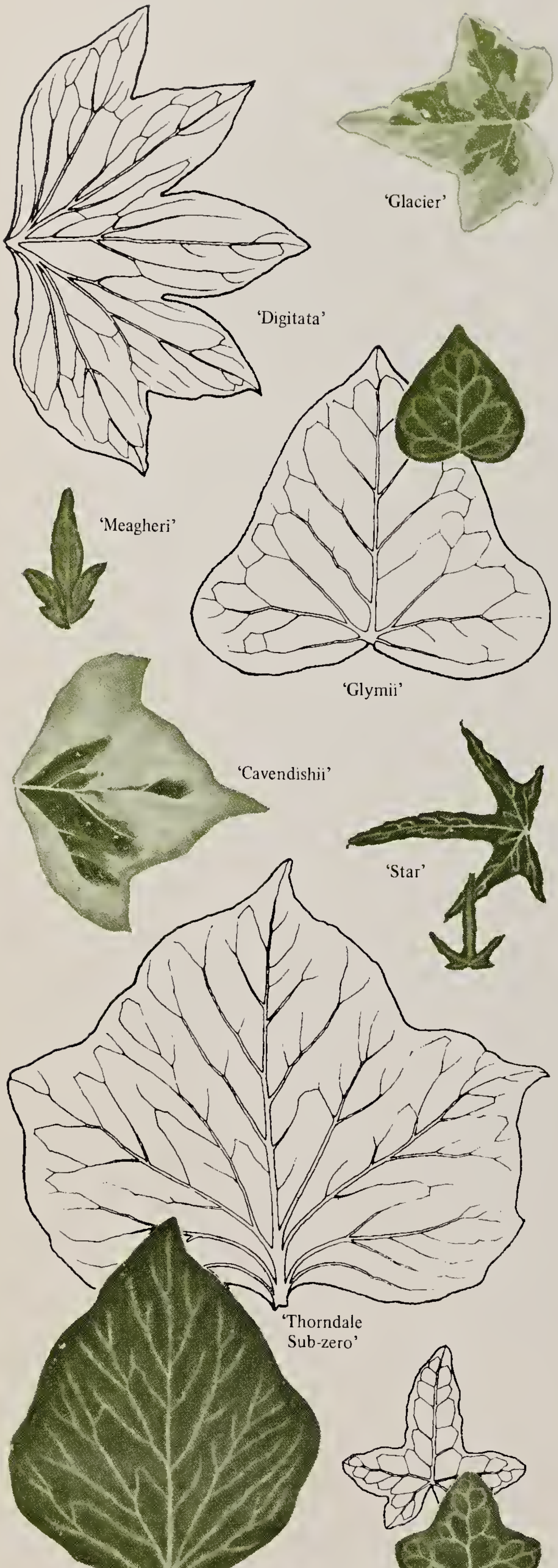
Or there may be only three veins, resulting in 3-pronged birdsfeet of every width, or, webbed between, in arrowheads and shields. Many have instead of three or five noticeable veins a spread of inconspicuous ones. These never have the rounded lower lobes of typical ivy but taper smoothly into the petiole and take on the shapes of fan and hand, often with the curve between pointed lobes a deep pleat.

Fortunately for us, most of these shapes can be found among what I think of as the "primitive" ivies, hardy forms that have been observed and collected not only in the British Isles but throughout northern Europe, from the last half of the nineteenth century into our own time. They tend to have long internodes, and they rarely branch or sprout shoots from their leaf nodes. Their length of petiole can vary considerably, however, with some as long as 6 inches, others so short as to appear almost sessile. The "primitive" cultivars are also the ones eventually to flower and produce seed. It is plausible that all of the old clones are variants from seed.

Do you find it hard to believe that the apparently endless green of ivy can flower at all? Creeping along the ground or beginning to climb, English Ivy displays what is called "juvenile" foliage. The leaf shapes described above are all versions of this juvenile, non-reproductive growth. But ivy's urge is ever upward and when a certain height has been reached, short twiggy branches develop with leaves that are at first unrecognizable as ivy. Gone is every vestige of a heart-shaped base and gone are lobes. Instead the leaves are oval, tapering to a point at either end, highly polished: even if the juvenile leaves are dull, these gleam. Such is the foliage of "adult" or mature wood, regardless of the leaf shape on young climbing growth.

Ivy is said to have become "arborescent" at this stage, tree-like, branching, but it is now ready to produce bloom. At the tips of those twigs, on some clones as early as August, on others not until October, appear rounded um-

[1] Drawings and excerpts reprinted by permission from House Beautiful. Copyright 1968 by The Hearst Corporation.



bels of buds that burst into flowers that are mostly green stamens. They are inconspicuous and never fail to surprise those who notice them for the first time, but I look forward to seeing their soft paleness—a lovely haze over the varnished black-green foliage—and so do the small bees and flies that come in droves and pollinate them. Like many flowers that are predominantly stamens, these have a faint scent of wild honey and almond similar to that of the English "May," *Crataegus oxyacantha*. The resulting black berries are well camouflaged. One variety of *H. helix, poetica,* has yellow berries. How I should like to see these instead!

I once assumed that *Hedera* branched out only when it could grow no farther; the eaves of old stone houses in the Philadelphia area are thick with horizontal masses of flowering ivy in late August. Now I realize that maturity occurs at a particular height for each cultivar regardless of the extent of support. Some are entirely arborescent, branching out and flowering at 3 or 4 feet. When grown from cuttings these in time make bushy shrubs of ivy, totally unexpected and handsome. Others start maturing at a reasonable height but continue to vine upward, casting long strands downward as they go.

Still others seem never to mature. There may be some correlation with leaf size for those that come to mind as non-arborescent are the small-leaved 'Walthamensis' and 'Meagheri,' both of which can reach 12 feet, and two others distinguished by having not only a minimum of petiole but internodes so short that the leaves appear stacked atop each other, or in effect braided together. The dark 'Conglomerata' has broad 5-lobed leaves, cupped and distinctively waved; some plants are prostrate, others upright. 'Erecta,' with triangular, troughed leaves in stiff, bright green ranks, at first glance resembles a spineless *Ilex Pernyi*. These two are the slowest-growing of hardy ivies.

English Ivy may reach 90 feet, but 50 feet is more probable. It climbs by aerial rootlets that dig into porous masonry or wood or bark, deriving no nourishment from its support. Should you let any of the more vigorous kinds assault your trees, resign yourself to keeping the eventual upper reaches under control and cut back annually.

While hardiness is of prime consideration when using ivy in our borderline zone, even more important is placement. After all, English

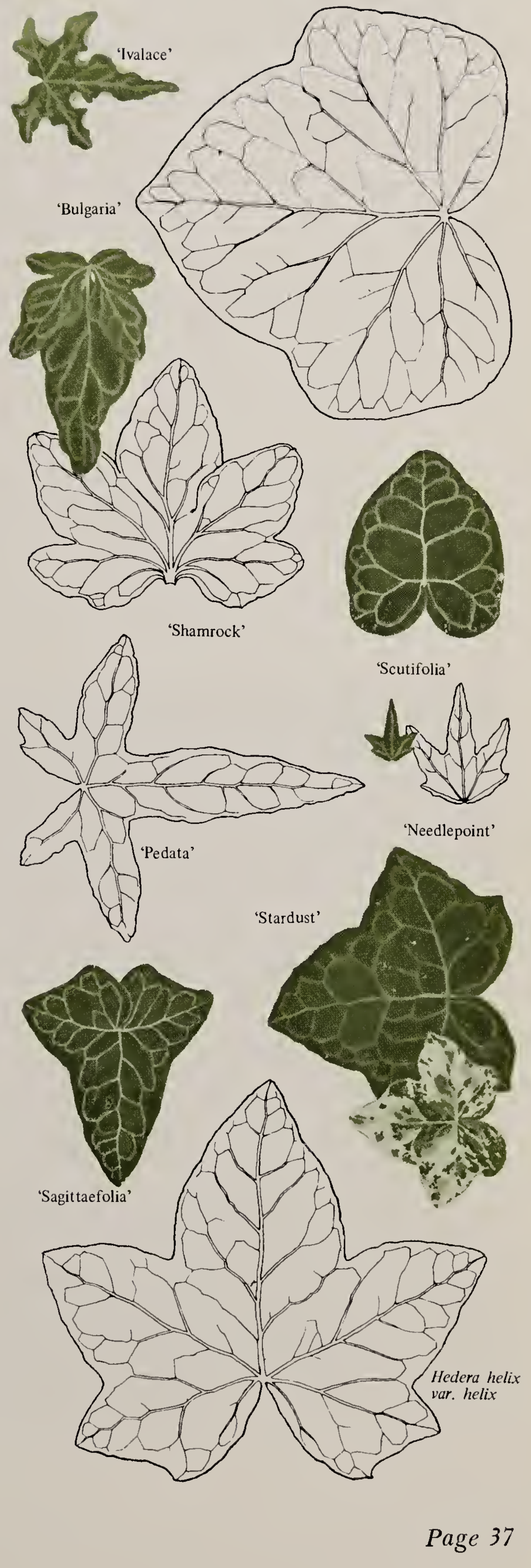
Ivy is a broad-leaved evergreen: the danger of winter to these is not extreme cold so much as high, desiccating winds and the waxing sun of February and March, burning in its intensity. Surfaces facing north or east are best. Used as a groundcover only, ivy comes through unscathed, especially with snow cover or a light mulch of non-packing leaves (sycamore, oak).

Most usually seen are those close to *helix*, with its gray-white skeleton of veins and ruddy coloring in winter, the leaves seldom exceeding a 2½-inch breadth. Botanical variety *hibernica* (Irish Ivy) has leaves 4 to 5 inches across, shallow-lobed, green-veined, easy to identify. Down the scale in size from *helix* is variety *baltica*, consistently smaller; 'Emerald Gem' which refuses to darken with winter; and smallest of these, 'Walthamensis' (Baby Ivy).

This last demonstrates a valuable trait of certain of the "primitive" ivies. Because they do not branch or sprout shoots from their nodes, they make unattractive pot plants, straggly, with little bulk of leaf. Only out-of-doors do they show their worth. Given a few years on ground, wall, or tree, their many strands interlace to make a 2-dimensional pattern of leaves, overlapping, scale-like, that is the essence of ivy's beauty. An isolated runner of 'Walthamensis' is all stem, little leaf, yet once established on the ground it makes an even blanket 4 inches deep, stems invisible, a lovely fabric of sooty green, white-threaded, no leaf larger than a single inch.

Now the sinuses, those spaces between the lobes, may either indent sharply, or disappear altogether! Here I find the most decorative of the hardy ivies. They are leather-textured sorts, short-stemmed, down-pointing, and in winter their deep matte green turns black or chocolate while their basic veins, often at right angles, remain ivory. 'Pedata' and 'Birdsfoot' are deepest cut and most vigorous, maturing heavily at 10 feet. 'Caenwoodiana' is regularly smaller, less cut. In bold 'Helvetica' and smaller 'Triloba,' the outline fills out, and in 'Sagittaefolia' the basal lobes overlap. The overlapping is repeated in 'Scutifolia' and 'Sweetheart,' whose leaves have no indentations at all but are long, rounded hearts or shields.

Recently there has been an addition to the list of hardy ivies, unlike any of these in shape, although it does have the long non-branching strands. In 'Manda's Crested,' the sinus is so ex-



panded that it rises up in a single great ruffle between each leaf point, while the five points bend downward. The effect is strongly 3-dimensional, so distinctive that it is simple to identify.

Showier though lacking vein pattern are the variegated hardy ivies, sports surely, of *baltica* or clones close to *helix*. Only 'Cavendishii' has real vitality. Its small, broadly triangular leaves are chartreuse splashed with green, with extremes of all one or all the other, and this mixture persists in the adult foliage that develops at about 7 feet. 'Discolor' ('Marmorata') has small leaves mottled—or coarsely salted—white on deep green, even on older leaves; with cold the white flushes to deep rose tones, too camouflaged to be effective out-of-doors. The variegated sport of *baltica*, 'Stardust,' displays this spackling only on the first ten or twelve new leaves, which recede then to monochromatic greens. This characteristic is most appealing in shade, for the sprigged whiteness is bold while it lasts and appears not to pinken with cold.

Cold brings a ruddiness to ivies that is sometimes assumed to be a permanent, year-round condition. It can sometimes occur with a drop of only 15 degrees. I have seen 'Manda's Crested,' grown cold (in a 50° greenhouse), turn an enchanting copper color, its texture netted like fine-threaded cloth on the bias, roll-hemmed, its identity ascertained only by the leaf form. Returned to warm house (night temperature, 60°), the leaves returned to green—but I rather liked those earlier copper curves, so unexpected.

At the same time, leaves of the variegated 'Glacier' nearby were rose-rimmed, literally 4-colored, while in the warmer atmosphere they were their usual cream, gray, and gray-green. This clone, long considered tender, has come through winters beautifully beneath a light mulch. Drawing apart the leaves or pine needles to gaze at its cheerful loveliness is one of the compensations of winter to the northern gardener.

One ivy that is currently offered as 'Purpurea' (and is probably 'Triloba') is deep chocolate only during winter, a trait of those cultivars with shield- or heart-shaped leaves, in no way unusual.

For sheer drama the arborescent ivies are unsurpassed. In the Arboretum's collection grow at least five that are primarily fruiting plants. Their masses of foliage are polished leather, a constant deep green in this climate. Judging from their height and bulk, they are as hardy as ivy can be.

'Glymii' has the smallest leaves, variations on heart and rhombus, under 1½ inches wide, cupped, maturing at 4 feet. '238th Street' is similar but larger, its juvenile leaves suggesting those of Lombardy Poplar, to 3½ inches wide, saucered. Flowering starts at 3 feet but so late in the season that winter often catches it still in bud. 'Crenata' ('Fan') begins with broad 7-pointed leaves which decrease in points as they increase in length, matures at 3 feet, and fruits heavily. 'Bulgaria' is particularly handsome, with smooth leaves of rounded triangles, seldom lobed, 3 inches at widest. What distinguishes them is a certain convexity that emphasizes their glossiness, noticeable far away. This flowers abundantly at 3 feet.

Largest of any ivy I know is 'Thorndale Subzero,' with young leaves broadly 3-lobed to 5 inches *as a rule*. Flowering begins at 7 feet but branching starts at the base, thick tufts of highly polished wedges and rhomboids in pale-veined deepest green—a spectacular ivy, hardy where all others fail.

Aside from the abrupt change in leaf form that occurs as *H. helix* emerges from adolescence to maturity, there is the factor of sporting to consider. While on aged vines of several of the "primitive" clones one may find at least six different outlines among the leaves, these are usually to be found at predictable stages in the development of a single strand or climbing shoot. Where the juvenile growth really begins to send out bud sports with abandon, ones that can be propagated vegetatively, is in the easy life of the greenhouse.

The first to be discovered to branch freely at the nodes, for instance, was 'Pittsburgh,' so named in 1920. Since then, ivies grown under glass have produced dozens of forms, some hardly distinct or stable enough to rate clonal names, yet as many as sixty-five are presently available. In 1963, EXOTICA 3 described eighty-three, and I have seen old plants of still others.

Most of these more recent ivies are branching and bushy, and so make good-looking potted plants. Set outside, though, they will either succumb to the first winter (or even sooner, to drought, or to an onslaught of red spider-mite) or else, slowly but certainly, will revert to the

type *helix* or something close to it. In our garden here I planted the diminutive 'Meagheri' ('Green Feather') years ago; it took on vigor with age. From slender, deep-cut, 3-parted leaves it went to broader, 5-parted ones like those of 'Fleur de Lis,' to something like 'Garland,' to the shallow-lobed *helix*. Any of these intermediate forms brought indoors would likely sport to the irreducible extreme, 'Maegheri,' in time. In the Arboretum is a vine so labeled, with leaves near the base typical *helix;* here and there are ones that might be 'Shamrock,' and only at the very tips of occasional strands can be found what is certainly 'Meagheri.' Knowing the behavior of my own plant, I have no doubt it was the correctly named, small-leaved ivy when first set in place.

I hope to tell about the many tender forms of *Hedera helix* in a subsequent article.

A Brief Description and Notes on the Cultivation of Primula Sieboldii

Angus Paxton Heeps

Siebold's Primrose, indigenous to Japan and Transbaikalia, a province of Western Siberia, was first introduced into the Western Hemisphere in 1861 by Messrs. James Veitch of London. This fine primrose had already distinguished itself as a useful garden plant in Japan, where it is known to have been in cultivation for more than 150 years.

Confusion over its nomenclature reigned for many years, some botanists claiming it to be a variety of *Primula cortusoides* Thunb., others maintaining that it was a distinct and separate species. Indeed, upon introduction it had been named *P. cortusoides* var. *amoena* by Lindley. This is only one of the many synonyms. There can be no doubt that *P. sieboldii* E. Morr. has been sold under the name of both *P. cortusoides* L. and *P. saxatilis* Komarow. To distinguish these species from each other, inspection of the flower parts will show that *P. Sieboldii* has calyx segments with widely spreading lobes, while the other two species have strictly adpressed calyx segments. Not until 1873 was a paper published by E. Morren, correctly classifying this plant as *P. Sieboldii.*

Whilst flower size may be attributed to such factors as environment and climate it is worth noting that this primrose consistently produces larger flowers than its close associates. These flowers are borne during May in a single terminal cluster on stems 6 inches to 8 inches tall, rising from a most attractive rosette of broad, fluted leaves (Fig. 1). Flower size varies from 1½ inches to 2 inches in diameter, and though pink is the typical color for this species, many selections have been made over the years that now enable us to obtain shades of purple, lavender and white.

Cultivation

It is a plant of great value to gardeners on the East coast since it has proved quite hardy and relatively trouble free with regard to cultivation. It is readily propagated from seed sown in early January in the cold frame or in the greenhouse in early March. Seedlings should be pricked out into a compost heavily enriched with

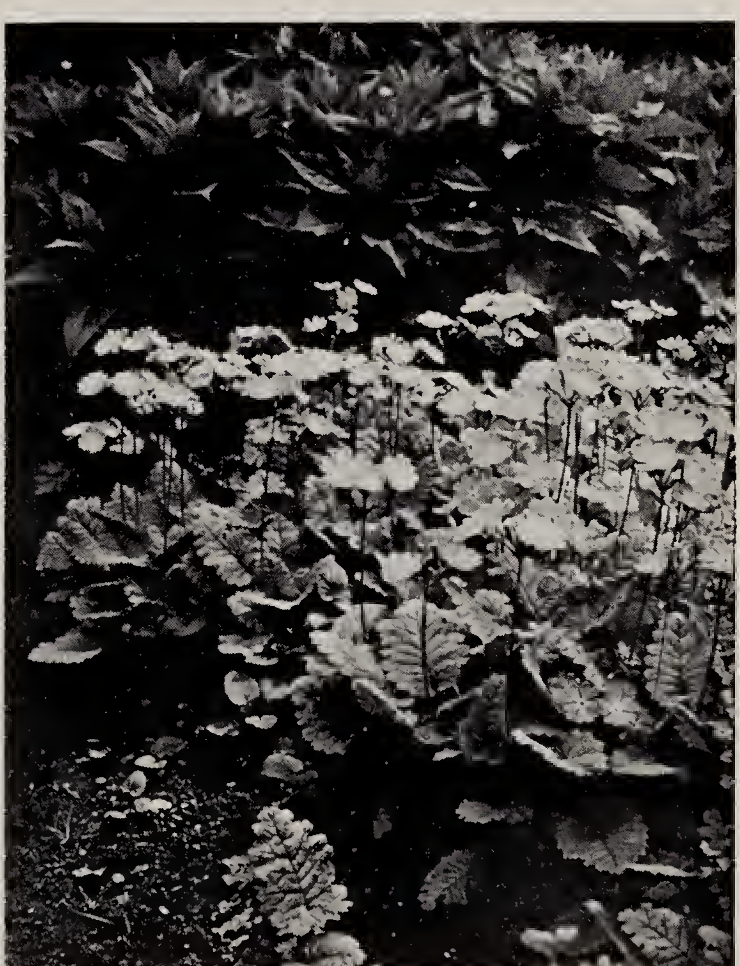


Fig. 1 *Primula Sieboldii.* Photo by A. Heeps.

leaf mould. Permanent planting should take place in early autumn. Propagating by division is a particularly successful method with this primrose but it is an operation to be carried out with best results after the flowering period and not in early spring.

Mature plants will begin to go dormant in July, not a typical habit of this genus, but in this case a very practical one since it means protection from the heat and humidity of an Eastern summer and avoidance of many pests and diseases that thrive in such conditions. Some protection of the dormant rhizomes in the form of leaves is necessary during winter. It should be remembered that drought at any time of the year is inimical to Primulas, particularly during spring and early summer, therefore, irrigation of the plants at such times is of prime importance.

P. Sieboldii will grow admirably in a rich moist soil in a lightly shaded position, such as the woodland, wild garden or rockery (Fig. 1). It should be placed in a location in which it is not likely to be disturbed, except for such reasons as propagation or removal. It is a plant of exceptionally fine form both in leaf and flower and its beauty in the garden can be greatly enhanced by planting it in association with *Brunnera macrophylla* or *Mertensia virginica.*

SYNONYMS OF PRIMULA SIEBOLDII E. MORR.

Primula cortusoides Thunberg (not Linnaeus).
Primula cortusoides var. *amoena* Lindley.
Primula cortusoides var. *grandiflora* Verschaffelt.
Primula cortusoides var. *patens* Turczaninow.
Primula patens Turczaninow.
Primula gracilis Stein.

REFERENCES

Balfour, Bayley. 1913. Japanese species of Primula. Jour. Roy. Hort. Soc. **39**: 174-179.

Blasdale, Walter. 1948. The Cultivated Species of Primula. Berkeley, Los Angeles & London. 284 pp.

Boynton, Kenneth. 1925. Primula sieboldii. Addisonia. **10**: 5.

Farrer, Reginald. 1922. The English Rock Garden. London & Edinburgh. **2**: 121-179, 182-183.

D., A. 1889. Primula sieboldii. The Garden. **36**: 318-319.

Index kewensis plantarum phanerogarum. 1893-1966. Oxford.

Klaber, Doretta. 1966. Primroses and Spring. New York. 125 pp.

Scott, Aleita. 1947. A Primrose for naturalizing. Jour. N. Y. Bot. Gar. **48**: 153-155.

Arboretum Activities

(Continued from Page 34)

research and disseminating such knowledge to the world. It is not, however, my purpose to restrict the Trustee to botanical research. It is my desire that the Foundation should publish books and pamphlets for distribution to the public . . . on the subject of the research work or other kindred subjects which may be thought useful or beneficial to the public."

Still to be realized is an expectation gracefully epitomized by the first Director of the Morris Arboretum, Dr. Rodney H. True, in the pamphlet prepared for the dedication ceremonies of the Arboretum on June 2, 1933. I quote as follows: "While the real researcher, true to his instinct, will research in an attic, we foresee in the future an adequate building designed and constructed on the most approved model, to which this and other laboratory work may be moved when the attic stage has been outgrown."

In the final address at the dedication ceremonies, Dr. A. Lawrence Lowell, President, Harvard University stated: "Approach to the dream requires faith; faith on the part of the instructing staff that it is possible; faith on the part of parents, alumni and the public that it is desirable; and mark you, if even an approach is made no man can predict how far it may be carried."

In direction of planning for the future was the removal of the sadly derelict Morris Mansion on September 12-16, 1968. During the same period, our administration building, Gates Hall, has undergone extensive, seriously-needed renovation including a new roof, repainting, a new ceiling and fluorescent lighting for the library, and construction of an attractive new office adjacent to the herbarium for Dr. Li. The ailing brick terrace has been resurfaced and a new iron stairway replaces the hazardous one descending to the gardens. Dr. Allison's essential facilities for preparation of media for culture of various fungi have been removed from crowded quarters on the second floor to new quarters in the basement thus providing more adequate space in her upstairs research laboratory. The dangerously corroded iron beams in the basement that support the brick terrace are now happily replaced by new construction.

(Continued on Page 47)

Factors Affecting Cold Acclimation of *Hedera helix*

Peter L. Steponkus
Assistant Professor of Ornamental Horticulture
Cornell University, Ithaca, New York

The distribution and use of woody ornamentals in beautification of man's environment is often restricted by the low temperature tolerance of the species. The many problems now posed by low temperatures and freezing, the single most limiting factor to plant distribution, will be multiplied as crop production and plant diversification are extended to new and less favorable regions of cultivation. In order to meet these problems, basic physiological research is required to elucidate how freezing kills plants and how tolerant plants acclimate to resist the cellular stresses imposed by freezing. Hopefully, elucidation of the cold acclimation process will result in artificial means to increase hardiness and expand the geographic distribution of any given species.

There are many types of injury resulting from winter conditions which are collectively referred to as "winter injury" or "winter kill." These include mechanical damage incurred by shade trees in full leaf by early heavy snowfalls, frost splitting of trees, sunscald, killing of annuals by early fall frosts, the destruction of buds of fruit trees by cold spells in the spring following early warming periods, the winter desiccation of broad-leaf evergreens such as *Ilex, Kalmia, Leucothoe* and *Rhododendron* species, and frost heaving of cultivated plants. While all of these problems come under the canopy of "winter injury" and are problems which must be considered in the cultivation of a species, they are not cold hardiness problems in the true sense of the word. Strictly speaking, cold hardiness is the ability or capacity of the plant to survive an unfavorable environmental temperature. The selection of ornamental plants for a given locality or hardiness zone is usually based on the lowest temperature that the species can endure and disregards the other factors. It is this killing point of the organism or minimum temperature that the plant can endure to which research on cold hardiness is directed. Two questions which are basic to such research are: 1) How does freezing kill plants? and 2) How do some plants acclimate to endure freezing temperatures?

Basis of Cold Hardiness

Cold hardiness of a given species is dependent on two factors: 1) the inherent or genetic capacity of the species to withstand freezing temperatures and 2) the conditioning or expression of the heritable capacity. Let us first consider the inherent or genetic capacity of cold hardiness. Immediately one can cite examples at both ends of the scale: very cold-sensitive species such as *Acacia, Citrus* and *Eucalyptus* and very cold-tolerant trees such as *Betula, Picea* and *Populus*. Regardless of what efforts are expended, *Citrus* species are able to endure only a limited amount of exposure to freezing temperatures because they lack the inherent genetic capacity.

However, even though plants possess the genetic capacity to survive freezing temperatures, this genetic capacity is a latent trait requiring certain *cues for expression*. Plants exhibit a periodicity of cold hardiness; in the winter they are able to withstand freezing temperatures of —50°F or lower, but in the spring and summer they are as susceptible to freezing temperatures as *Citrus* species. *Hedera helix*, for example, can survive temperatures of —30°F when at maximum hardiness during the winter, but is easily killed during the summer by temperatures of +25°F. Thus, under certain circumstances trees and shrubs with the genetic capacity for cold hardiness cannot endure freezing temperatures. Expression of the genetic capacity of cold hardiness is known as cold acclimation. In summary, plants lacking the genetic capacity are considered *unhardy* or *frost-sensitive* plants. Plants possessing the genetic capacity but which have not experienced the proper environmental cues for its expression are considered to be in an *unhardy condition*. Plants with the genetic capacity and which have received the proper environmental cues are considered to be in a *hardy condition*.

Studying Acclimation

In order to study the phenomenon of cold acclimation, the research worker begins with a species which possesses the genetic capacity and studies the changes occurring during its expression. In choosing such a species, the latitude of choice is still quite great. One is immediately impressed with reports of twigs of *Cornus*

(Weiser, 1965) or *Morus* (Sakai, 1960) surviving temperatures below —125°F. After closer consideration however, the ability to withstand these ultra-low temperatures is not very intriguing, for one can reason that if a plant can withstand —30° or —50°F why not —125°F? After all, at —30° or —50° the great majority of water within the plant is now frozen and further decreases in temperature would not appear to be harmful. It now becomes apparent that plants of intermediate hardiness are more intriguing than the super-hardy species. Stem tissue of *H. helix,* at maximum hardiness, is able to survive —30°F but a further 10° drop in temperature is lethal even though the great majority of water was already frozen.

If cold acclimation is defined as the expression of the genetic capacity for cold hardiness, what environmental cues are responsible for this expression? Cold acclimation of woody plants involves a number of complex changes influenced by many environmental factors. The two most critical factors are light and low temperature (Levitt, 1956). The shortening days of autumn, through a process known as photoperiodism, reduce the growth rate, induce dormacy and, finally in deciduous species, leaf fall.

In Figure 1, cold acclimation studies of *H. helix* L. 'Thorndale' growing at Lafayette, Indiana are depicted. Beginning September, 1965, leaves and stems from 2-year and current year's growth were sampled at biweekly intervals until March, 1966. In determining the points for the acclimation curves, samples were subjected to varying sub-freezing temperatures then analyzed for survival. At the same time daily minimum and maximum temperatures were recorded. Hardiness started to increase during the interval from September 21 to October 5 when the minimum night temperatures were 40°F or below. Increases in hardiness proceeded until January 25, 1966 and paralleled the downward trend in the daily minimum temperatures. For a period between November 29, 1965 until December 29, 1965 the daily minimum and maximum temperatures remained static and hardiness also remained constant during this period. Hardiness increased further as the daily temperatures resumed declining. The ultimate hardiness attained was -18°F for 2-year-old leaves and -22° for 1-year-old leaves and -33° and -35° for 2-year and 1-year-old stems, respectively. After January 28, 1966, the daily temperatures began to increase rapidly and the hardiness showed a corresponding decrease at this time. The study was discontinued after March 8, 1966.

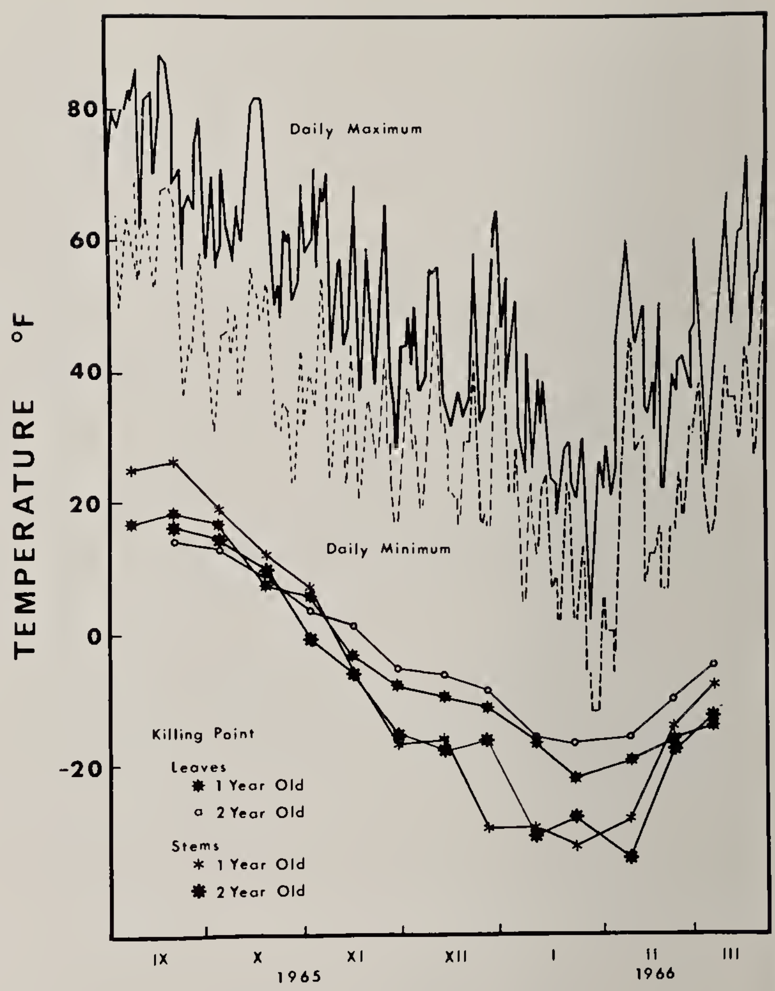


Figure 1. Cold acclimation of *Hedera helix* L. 'Thorndale' under natural conditions.

Acclimation in the Laboratory

Many of the recent advances in the knowledge of cold acclimation are the result of "artificial induction" of cold hardiness followed by controlled freezing conditions and suitable means for determining plant survival. While artificial conditions have greatly accelerated research progress, poor definition of conditions may not only affect reproducibility, but also the validity of interpretations made from such experiments. Points of prime importance include 1) comparison of cold acclimation under natural conditions to artificially induced cold hardiness, 2) standardization of parameters involved in artificial freezing tests, such as rate of freezing and time at a given temperature, and 3) determination of a representative sampling technique.

The standardized procedure for artificial cold acclimation of *H. helix* (Steponkus and Lanphear, 1967) is to place intact plants at 40°F for a period of 6 weeks. During this time an 8-hour photoperiod is provided by a combination of cool-white fluorescent lamps supplemented with incandescent lamps which provide a light intensity of 600 ft-c at plant level. Irrigation is supplied as necessary, usually at weekly intervals.

Plants exposed to artificial cold acclimation conditions for 6 weeks increased in hardiness to 1.5°F and -4.5°F for leaves and stems, respectively. Hardiness under natural conditions during the first 6 weeks increased to -4.5° and -5.0° for leaves and stems of current year's growth (which was comparable in age to plants artificially cold acclimated). Thus, 6 weeks' exposure to artificial conditions elicited increases in hardiness that were virtually the same as the hardiness attained under natural conditions. Leaf hardiness was slightly less under artificial conditions, but still comparable to that attained naturally. However, under natural conditions, hardiness of both leaves and stems continued to increase while under artificial conditions further increases in hardiness (at 40°F) were only slight.

Exposure to Sub-Freezing Temperatures

In some deciduous species exposure to subfreezing temperatures is required to stimulate maximum hardiness (Tumanov and Krasavtev, 1959; van Huystee, 1964). Therefore, studies were initiated to determine if the ultimate hardiness of *H. helix*, a broadleaf evergreen, was similarly influenced by freezing temperatures. A group of plants was exposed to an 8-hour photoperiod and the following temperature regimes: 2 weeks 40° days/40° nights; 2 weeks 40° days/30° nights; 2 weeks 40° days/20° nights. Another group was exposed to an 8-hour photoperiod and 40° for 2 weeks followed by continuous darkness at 30° for 2 weeks and 2 weeks at 20°. A control group was maintained under an 8-hour photoperiod at 40°. When the hardiness was determined after 6 weeks, there was no significant difference in hardiness of the plants. This may indicate that the requirements of the cold acclimation process of *H. helix* are different from those reported for deciduous materials (Tumanov and Krasavtev, 1959; van Huystee, 1964) and similar to those reported for *Taxus* (Zehnder and Lanphear, 1966). However, when one considers that soil and air temperature and time and duration of exposure to freezing temperatures vary greatly in nature, the precise regime probably was not artificially duplicated.

Acclimation of Cuttings

In conjunction with cold acclimation at freezing temperatures, it was desirable to determine if acclimation of cuttings was similar to that of intact plants. Intact plants were placed under an 8-hour photoperiod at 40°F, and after 3 weeks all plants were placed in the dark either at 40° or 30°. Plants of one group at each temperature were severed from their root systems. Aerial portions of all plants, regardless of whether or not they were severed from their root systems, were enclosed in polyethylene bags to suppress desiccation. After 6 weeks, hardiness of stems was not significantly different in any of the treatments. Leaves from detached plants at 30° were significantly hardier than leaves from intact plants at 40°. However, considering either temperature alone, removal of the root system did not significantly increase hardiness. Similarly, considering either cuttings or intact plants alone, freezing temperatures again did not significantly increase hardiness. While it is possible that enclosure in the polyethylene bags could have modified the atmosphere during acclimation, hardiness was similar to that obtained in previous experiments.

The Influence of Light

Previously, it was stated that light as well as low temperature is essential for cold acclimation. Although the light-responsive mechanism is not adequately understood, it appears that light can influence cold acclimation either photoperiodically or photosynthetically depending on the species and stage of cold acclimation. Apparently winter annuals are incapable of cold acclimation in the absence of light (Dexter 1933a, 1933b; Levitt, 1956) while deciduous species become acclimated quite satisfactorily in the dark (Sakai, 1962; van Huystee, 1964).

The photoperiodic response has most often been reported to occur prior to exposure to cold temperatures (Vasilyev, 1961); in responsive species, short days initiate cessation of growth and development of dormancy prior to cold acclimation. While the effect is most dramatic in deciduous species, as evidenced by leaf fall, short days prior to cold induction also increased hardiness of *Taxus* (Zehnder and Lanphear, 1966) and *Citrus* (Ivanov, 1940; Young 1961). In nature, photoperiodic induction of dormancy almost always precedes induction of cold hardiness by low temperatures. This natural sequence has fostered the theory that plants must be dormant before they can become cold acclimated. Irving and Lanphear (1967) have shown that this may be a false assumption, at least in *Viburnum*. *Virburnum* plants could become acclimated even though they were not in the dormant state, but

acclimation of dormant plants resulted in increased levels of hardiness.

There are very few reports of photoperiod influencing cold acclimation during the period when plants are exposed to low temperatures. Exceptions are some northern ecotypes of alfalfa which increased in hardiness under short days while southern ecotypes failed to respond to photoperiod (Hodgson, 1964). Andrews (1960) also reported an apparent photoperiodic response of wheat which failed to harden under a 24-hour photoperiod, but the results are difficult to interpret due to a temperature interaction resulting from the increased light duration.

The Implication of Photosynthesis

In the instances where light stimulates cold acclimation at low temperatures, the bulk of the data indicate a photosynthetic role (Kohn and Levitt, 1965; Levitt, 1956; McGuire and Flint, 1962; Tumanov and Trunova, 1963). However, rigorous proof of this point is lacking, as increased durations of light fail to promote proportional increases in hardiness (Kohn and Levitt, 1965; McGuire and Flint, 1962). Kohn and Levitt (1965) conclude that photoperiod affects cold acclimation of cabbage by increasing the amount of photosynthetic reserves. However, there was only a 5° difference in hardiness of plants exposed to photoperiods ranging from 8 to 24 hours. Also, in the frequently cited study of Dexter (1933a), plants exposed to CO_2-free air failed to harden in the light, but judging from photographs, the plants appear to be on the brink of death prior to freezing, solely as a result of the exclusion of CO_2. Another aspect that makes one suspicious of a photosynthetic role of light is the extremely low light intensity required for stimulation of maximum hardiness. In fact, Tysdal (1933) found that light intensity was important only when it reached a minimum so that it weakened the plant, which is similar to the results of CO_2 deprivation (Dexter, 1933a).

In *H. helix*, light greatly enhances the degree of hardiness attained, but cold acclimation is not obligately linked to a light requirement (Steponkus and Lanphear, 1966, 1968). Hardiness of leaves and stems from plants hardened in the dark was 13°F and 10° F, respectively. Exposure to photoperiods varying from 8 to 24 hours, at two light intensities, 60 and 600 ft-c, resulted in plants with leaves and stems hardy to -8°F and -11°F, respectively, with no significant difference between photoperiods or light intensities.

As found by other workers (Kohn and Levitt, 1965; McGuire and Flint, 1962), proportional increases in cold hardiness were not induced by increased photoperiods. The possibility existed that such a demonstration was not possible because the amount of photosynthates (sugars) produced during the shortest photoperiod were more than enough for (i.e., were saturating) the requirements for cold acclimation. To further investigate the possibility, plants were pre-starved by placing them in darkness at 40°F for 2 weeks. Following this the plants were subjected to various photoperiods (0, 2, 4, 8 and 16 hours) for 2 and 4 weeks at 40°F. By using shorter photoperiods or pre-starved plants any correlation of increased hardiness with increased photoperiods should be amplified. After 4 weeks at 40°F (2 weeks dark followed by 2 weeks light), stem tissue did exhibit increases in hardiness that were proportional to the photoperiod. After 6 weeks, the differences were less pronounced, and light saturation of the cold acclimation process was promoted by a photoperiod between 4 and 8 hours. Leaf samples did not exhibit such a proportionality in hardiness in response to photoperiod after either 4 or 6 weeks. A 2-hour photoperiod was still saturating the light requirement for maximum hardiness.

Additional Evidence

Further studies were initiated to resolve the threshold value of light intensity required for maximum cold acclimation. Plants were subjected to the standard acclimation conditions at light intensities varying from 0 to 800 ft-c (8-hr photoperiod). Maximum leaf hardiness was reached at an intensity of approximately 50 ft-c, while approximately 250 ft-c was required to stimulate maximum stem hardiness.

To substantiate the hypothesis that the role of light in cold acclimation is photosynthetic, plants were placed under conditions of selective deprivation of CO_2 during the cold acclimation period. If CO_2 was removed during the light period of each day or was withheld constantly during the acclimation period, stem hardiness was only slightly, but significantly decreased with respect to plants continuously exposed to CO_2 or those receiving CO_2 only during the light period. However, in neither case was hardiness decreased to the level experienced under dark conditions.

Thus, while the data indicate that the role of light in cold acclimation of *H. helix* is photo-

synthetic, the amount of photosynthates required to saturate the requirements of the cold acclimation process is only a small proportion of the total amount of photosynthates produced. This is further supported by the fact that the light requirement can be replaced by incubation on low concentrations of sucrose (less than 2%) (Steponkus and Lanphear, 1967).

Other Seasonal Changes

The fall-winter season is a time of great changes in the development of woody plants. Gross changes, such as the development of autumn coloration, leaf abscission, growth cessation and bud dormancy are readily observable. During this time, the plant is also preparing to endure the low temperatures of winter.

In *H. helix* the growth rate is dramatically slowed down during the autumn, mainly in response to lowered temperatures. This is in contrast to many deciduous trees and shrubs in which cessation of growth and development of dormancy are photoperiodically triggered. Although at 40°F growth is almost imperceptible, true dormancy is not encountered in *H. helix*, 'Thorndale,' true dormancy being defined as the inability to produce normal growth under favorable environmental conditions. Rather, *H. helix* becomes quiescent and the limitation of growth results from unfavorable external conditions. Although growth is not favored, the short days and low temperatures do favor sugar accumulation and increases in the anthocyanin (red pigments) content of leaves and stems. Usually the leaves will become so heavily pigmented that they will appear black, while the color of young stems will increase in intensity to a vivid red. Under natural conditions, the increase in anthocyanin content in *Hedera* parallels the increase in cold hardiness, and in spring both decline in unison (Parker, 1962). The coincidence of the two processes has led many to believe that the two processes are causally related. However, under artificial conditions, anthocyanin synthesis can be eliminated or stimulated without any effect on the hardiness of *H. helix* (Steponkus and Lanphear, 1969). Thus, visual changes may be more misleading than helpful in elucidation of the cold acclimation process.

Other Aspects of Acclimation

Up to this point only factors *influencing* the acclimation have been discussed, we have still not addressed ourselves to the two questions 1) How does freezing kill plants? and 2) How do some plants acclimate to endure freezing temperatures?

In order to gain further insight into the cold acclimation process we need to probe into the metabolism of individual cells. Many biochemical changes that occur during cold acclimation have been investigated; increases in the sugars, water-soluble proteins, amino acids and lipids, as well as decreases in starch content have been recorded. The problem that remains is to determine which of these changes are causally related to the cold acclimation process and which are merely coincidental events. Before we can do this, however, it is important that we know something about the details of freezing injury.

Literature Cited

Andrews, J. E. 1960. Cold hardiness of sprouting wheat as affected by duration of hardening and hardening temperature. Can. J. Plant Sci. 40: 94-103.

Dexter, S. T. 1933a. Effect of several environmental factors on hardening of plants. Plant Physiol. 8: 123-139.

Dexter, S. T. 1933b. Decreasing hardiness of winter wheat in relation to photosynthesis, defoliation and winter injury. Plant Physiol. 8: 297-304.

Hodgson, H. J. 1964. Effect of photoperiod on development of cold resistance in alfalfa. Crop Sci. 4: 302-305.

Irving, R. M. and F. O. Lanphear. 1967. Environmental control of cold hardiness in woody plants. Plant Physiol. 42: 1191-1196.

Ivanov, S. M. 1940. Frost resistance of citrus plants as controlled by daylength. Comp. Rend. Acad. (Doklady) Sci. URSS. 28: 736-738.

Kohn, H. and J. Levitt. 1965. Frost hardiness studies on cabbage grown under controlled conditions. Plant Physiol. 40: 476-480.

Levitt, J. 1956. The hardiness of plants. Academic Press, New York.

McGuire, J. J. and H. L. Flint. 1962. Effects of temperature and light on frost hardiness of conifers. Proc. Amer. Soc. Hort. Sci. 80: 630-635.

Parker, J. 1962. Relationships among cold hardiness, water soluble protein, anthocyanins and free sugars in *Hedera helix* L. Plant Physiol. 37: 809-813.

Sakai, A. 1960. Survival of the twig of woody plants at -196°C. Nature. 185: 393-394.

Sakai, A. 1962. Studies on the frost hardiness of woody plants. I. The causal relation between sugar content and frost hardiness. Contr. Inst. Low Temp. Sci. 11: 1-40.

Steponkus, P. L. and F. O. Lanphear. 1966. The role of light in cold acclimation of woody plants. Proc. XVII Intl. Hort. Cong. I: 93.

Steponkus, P. L. and F. O. Lanphear. 1967a. Factors influencing artificial cold acclimation and artificial freezing of *Hedera helix* 'Thorndale.' Proc. Amer. Soc. Hort. Sci. 91: 735-741.

Steponkus, P. L. and F. O. Lanphear. 1967b. Light stimulation of cold acclimation: production of a translocatable promoter. Plant Physiol. 42: 1673-1679.

Steponkus, P. L. and F. O. Lanphear. 1968. The role of light in cold acclimation of *Hedera helix* L. var. Thorndale. Plant Physiol. 43: 151-156.

Steponkus, P. L. and F. O. Lanphear. 1969. The relationship of anthocyanin content to cold hardiness. HortScience. (In press).

Tumanov, I. I. and Krasavtev. 1959. Hardening of northern woody plants by temperatures below zero. Soviet Plant Physiol. 6: 663-673.

Tumanov, I. I. and T. I. Trunova. 1963. First phase of frost hardening of winter plants in the dark on sugar solutions. Soviet Plant Physiol. 10: 140-149.

Tysdal, H. M. 1933. Influence of light, temperature, and soil moisture on the hardening process in alfalfa. J. Agr. Res. 46: 483-515.

van Huystee, R. 1964. Cold acclimation and accompanying metabolic changes in Red-osier Dogwood with special emphasis on proteins. Ph.D. Thesis, University of Minnesota, St. Paul, Minnesota.

Vasilyev, I. M. 1961. Wintering of plants. Translated from Russian by Royer and Roger, Inc.

Weiser, C. J. 1965. Principles of hardiness and survival as they relate to newly propagated plants. Proc. Intl. Plant Prop. Soc. 1965 Ann. Mtg.

Young, R. H. 1961. Influence of daylength, light intensity and temperature on growth, dormancy and cold hardiness of Red Blush grapefruit trees. Proc. Amer. Soc. Hort. Sci. 78: 174-180.

Zehnder, L. R. and F. O. Lanphear. 1966. The influence of temperature and light on cold hardiness of *Taxus cuspidata*. Proc. Amer. Soc. Hort. Sci. 89: 706-713.

Our Unique Filmy-fern Grotto

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At the west end of the Arboretum fern house, the pathway crosses a rustic bridge in front of a hollow in the wall, 10 feet high and broad, and extending in about 6 feet. This is lined by slabs of mica-gneiss rock, held in place by inconspicuous layers of cement, arched over at the top. The water of the pool extends into its base, so that its atmosphere is continuously moist. Early in the morning it is briefly touched by sunlight, but most of the day it is only dimly lighted (Fig. 1).

Fig. 1. Interior of the fernery showing the Filmy-fern grotto beyond the bridge.

Fig. 2. *Filmy-fern frond.* Photo by P. Allison.

The interior of this structure is lined nearly to the top by a luxuriant growth of an unusual fern. Its intricate network of slender, hairy rootstocks clings to the rock, and sends out numerous fronds with lacy blades around 6 inches long. These are only one cell thick and correspondingly translucent, with a striking play of dark and light green coloring. These features place it in the Filmy-fern family (*Hymenophyllaceae*) (Fig. 2).

No sporangial structures have been observed to develop, so that the species represented can not be ascertained with complete certainty, but its morphologic details correspond to those recorded as characterizing the Showy Bristle-fern, *Trichomanes speciosa* Willd., a view concurred in by Mr. Conrad V. Morton of the Smithsonian Institution, in the herbarium of which a specimen has been filed. According to the Flora Europaea, this species is native from the islands of the Azores and Spain, north to scattered points in the British Isles.

No record seems to have been kept as to when or by whom this fern colony was started. When the staff of the Botany Department of the University of Pennsylvania first visited the fern house in 1933, the plant covered only about half the vertical surface, so its subsequent expansion to virtually complete occupancy indicates that its cultural requirements have been met. So far as known, this constitutes the country's only thriving Filmy-fern grotto.

Cover Photo Note

The photograph on the cover of this issue was made from an 8 by 10 inch glass negative. This plate, along with many other interesting ones, was recently found stored away in what was once the Morris carriage house. The name of the photographer is unknown, but the picture was taken in November, 1900. The bridge and Filmy-fern grotto may be seen on the right.

Arboretum Activities

(Continued from Page 40)

Under the able direction of our new Superintendent, Mr. Heeps, considerable progress is being made in the revision, maintenance and care of the grounds and plant collections. Such overgrown areas as the zone surrounding the swan pond are now substantially cleared thus providing spaces for new development and introduction of appropriate new specimens. The interior of the greenhouse for tender medicinal plants has been completely repainted while the associated propagating and fern houses are awaiting completion of the most urgently needed repairs this coming Spring. A bed to the north of the Baxter memorial area has been cleared and will be prepared this winter for the planting of new examples of *Rhododendron* next spring.

Vandalism is never a pleasing topic. Unfortunately there has been increase in the incidence of unpleasant occasions resulting in damage to the Arboretum collections and facilities. In an effort to reduce such vandalism and to conserve the Arboretum for its major purposes, the establishment of moderate restrictions has been unavoidable. Recently, arrangements have been made for professional, uniformed guard service on week-ends. The Arboretum remains open to the public daily from 9:00 a.m. to 5:00 p.m. Children under age 14 are to be accompanied by an adult.

On July 18th it was a pleasure to welcome to the Arboretum Dr. Richard Lighty and a group of graduate students who are enrolled in the highly significant and promising program for the Master's degree, with concentration in Horticultural Administration, supported jointly by the University of Delaware and the Longwood Gardens.

The Staff

During his Fulbright tenure in Taiwan, Dr. Li presented a lecture entitled "Geographical Distribution of Conifers and Taxads" before the Department of Botany, National Taiwan University, Taipei, on July 6, 1968. He also lectured on "Modern trends in plant taxonomy" at the Science Seminar, Academia Sinica, Taipei, on July 28th. As a Fellow, Dr. Li attended the biennial meeting of Academia Sinica on July 30th. His research on the "Flora of Taiwan" continues and, in collaboration with Dr. J. J. Willaman, the investigatons on "Alkaloid plants" are well underway towards completion.

During the week of September 15th, Mr. Heeps and the Director attended the annual Congress of the American Horticultural Society and the accompanying meetings of the American Association of Arboretums and Botanical Gardens in San Francisco. Rewarding experiences included visits to the Strybing Arboretum and the fascinatingly varied collections of the Botanical Gardens at the University of California, Berkeley.

A. Orville Dahl

Morris Arboretum Bulletin

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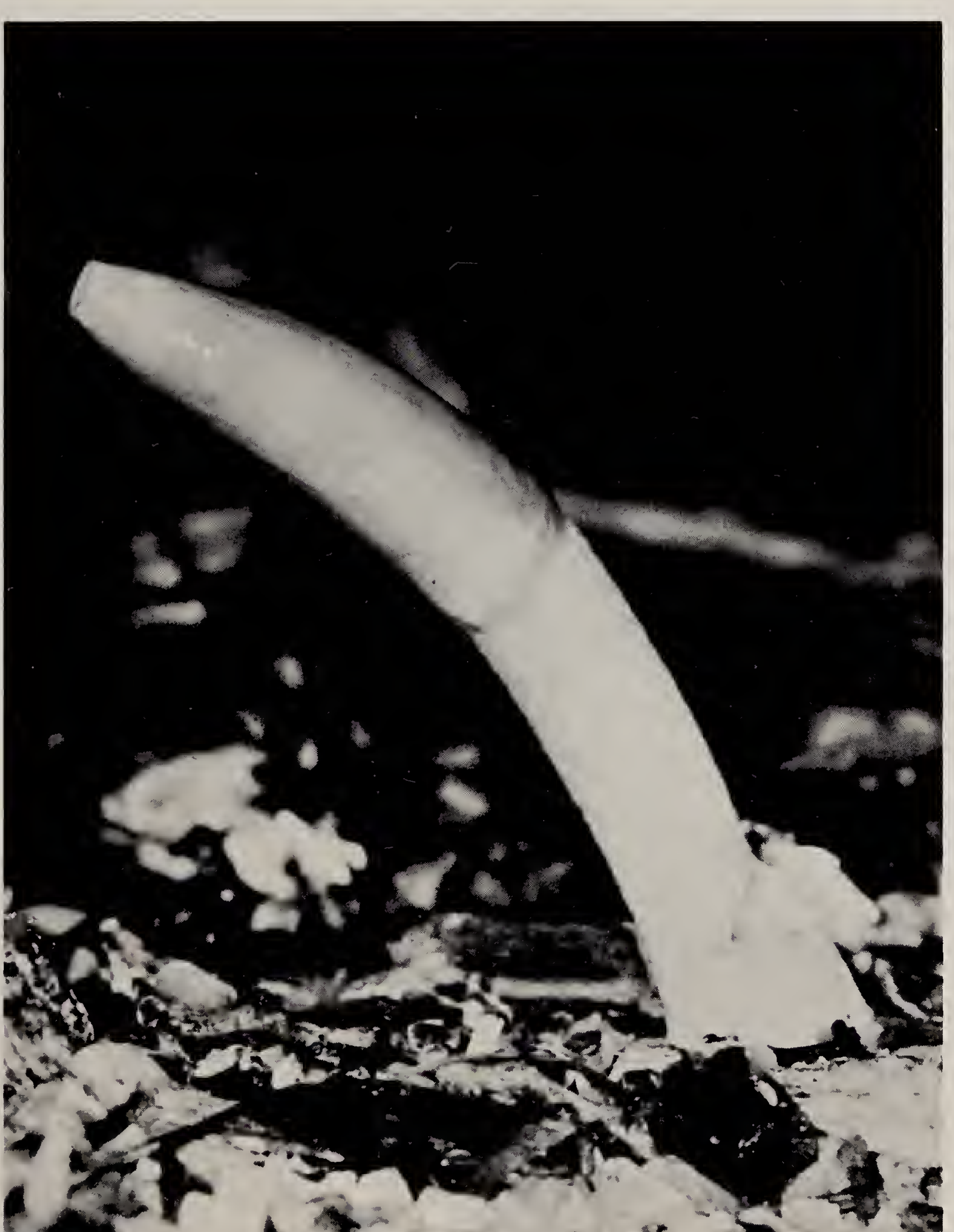

Mutinus caninus

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THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Arboretum.

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Sustaining ....$10.00 a year	Sponsoring ....$100.00 a year
Supporting ....$25.00 a year	Donor $500.00

Arboretum Activities

It is with considerable regret that we report the passing of one of our devoted staff, Mr. William Murray, who served with distinction as Senior Gardener from March 24, 1966 until his death on November 10, 1968. Mr. Murray contributed substantially to the Arboretum in many ways. Particularly notable was his skilled and enthusiastic handling of major improvements in the Fernery and the Rose Garden. We extend heartfelt sympathy to his parents Mr. and Mrs. Murray of Glasgow, Scotland and his aunt, Mrs. Mary Cronin of Chestnut Hill.

Currently, we continue to be in transition with reference to the preparation and editing of materials for the coming numbers of the *Bulletin.* Our Editor, Dr. Patricia Allison, is organizing an excellent program of articles which should provide for a continuum of well-balanced publications of general, botanical and horticultural interest.

(Continued on page 59)

Ants, Aphids, and Stinkhorns

Patricia Allison

First The Stinkhorns

There can be no doubt about it; members of the order Phallales are impressive fungi. They are Basidiomycetes, as are the rust and smut fungi, the coral and bracket fungi, and the mushrooms of the market and field. Their closest relatives, however, are the puffballs, bird's nest fungi, and earth stars, a diverse group thought by some (15, 19) to be at the very pinnacles of development in the fungal kingdom, and also (15) to be at highly experimental stages in evolution.

If experimental they are, the objective of the grand Phallales game seems to be dispersal by insects. Two broad stratagems are obvious. One has been the development of frilly fructifications of resplendent hues, and has earned them one of their common names, "fungal flowers". The other has been the compounding of a sticky, greenish mixture of spores, sugar, and scent that is so effective a potion in its most highly developed state that blow-flies and carrion beetles find it utterly irresistible. A great many human beings find it utterly disgusting, and give the fungi a second common name, "stinkhorns". When lacey form and vile odor are combined in one species, the effect is devastating.

The stinkhorns exist in greatest variety in tropical areas, but some species are more widely distributed and abundant than most (20). One or two, thought to reach the northern limits of their range in the southern United States, have occasionally been found much farther north. The small size and brief life of such forms probably account in part for the paucity of reports. Altogether there are about 20 genera.

The fructifications usually are attached to the feeding filaments by ropey aggregates of hyphae. Rotten branches, wood chips, and buried wood are common substrates, but fruiting also occurs on rich soil, even in lawns and gardens. As with many fleshy fungi, periods of abundant moisture allow rapid development of the fruiting bodies, but at least one species is notable for the sogginess of its habitat. Late summer and autumn are the times to look for the stinkhorns.

Basic to the success of the two stratagems of dispersal is the development of the spore-bearing structure. Like many fetid flowers that are pollinated by insects sensitive to their odors and that open in the afternoon only to spend their entire effective existence in a single night, the stinkhorns erupt suddenly, and the spore burden may be cleanly licked away in a few hours.

The nearly mature fruiting body is deceptively simple. It resembles a small puffball, varying with species from about a half inch in diameter to two inches or so. It might even be taken for a mushroom in the button stage. The resemblance is superficial however, for inside is an organization so different from either of these that early developmental stages can be homologized with those of other Basidiomycetes only with the greatest difficulty. It is easier to mention the extraordinary features of the mature structure first than to begin with the peculiar contents of the stinkhorn "egg".

The simplest mature stinkhorn is a turgid, hollow column of spongy tissue, the receptacle, that has at its base the torn remnants of the skin of the egg. The column itself is most often some shade of orange-red, and can be quite brilliant. The tip is usually open. Just below it the receptacle is covered with the greenish brown slime that bears the basidiospores and emits the odor. At first this part is somewhat firm, and may be covered with a fragile, veined transparent membrane. Before long, however, the gleba, as it is called, becomes more liquid and the odor more intense. The whole mass can slip part way down the shaft. Members of the genus *Mutinus* with structure like this are commonly encountered in temperate regions (Fig. 1.). They vary in length from about two to seven inches.

Members of the genus *Phallus* are a good deal bulkier and complex. The hollow, spongy receptacle is thicker walled, wider, and can be ten inches tall. It is white or nearly so. What is lacking in color is made up for by the texture (Figs. 2 and 3.) At the top, the gleba coats a cone-shaped flap of tissue that hangs from its attachment around the edge of the apical opening of the stalk. The flap, or pileus, may itself be ornamented with reticulate ridges. The gleba liquefies, reeks, and can be completely lapped up by flies in only two to three hours (14). *P. Ravenelii* (B. & C.) grows in low, wet places,

where during warm autumns, the fructifications develop in great troops. Stumbling on a hidden branch or slipping on wet clay can pitch one squarely in their midst, an experience that is the esthetic equivalent to kicking open a hornets' nest.

Fig. 1. *Mutinus caninus*

Between the cap and stalk there may be another, sterile flap of tissue in some specimens of *Phallus*. It is in the astonishing genus *Dictyophora* that this underskirt is always present and highly developed. A. Möller studied the "Pilzblumen" (Fungus flowers) of Brazil before the turn of the century. It is his illustration of *D. indusiata* (Pers.) Fischer (13) that shows the greatest development of the snow-white, netted veil that spreads away from the stalk far below the lower rim of the pileus. Our own species, *D. duplicata* (Bosc.) Fischer, is by no means put in the shadow, however.

An egg that was found at the Arboretum one October was put on several moist paper towels beneath a large bell jar in the laboratory. Ten days passed, and hope of its hatching had nearly vanished. Then during the night, the splendid fruiting body expanded. From the egg, which was about two and a half inches in diameter, came a stalk approximately seven inches high. The cap was still dull olive green, for the gleba had not yet liquefied. The expanding indusium (underskirt) hung beneath the cap. The next day the gleba was shining and dark, and had begun dripping downward. The meshes of the lacey apron had expanded still more. Taking photographs was an incredible challenge as it required the removal of the bell jar, but enduring the dreadful stench of this beautiful fungus was made the easier by the thought that the specimen (and the experience) would be passed along to one's graduate students.

There really is a variety of tastes. Alexander H. Smith tells of one of his encounters with this species (20). "Once while collecting fungi with other students we smelled a phalloid and tried to trace it down in order to learn the species, but it seemed to keep moving. Finally, we noticed that an old man was also in the woods collecting fungi, and as I worked over toward him I realized that a phalloid of some kind was very close. After greeting the old gentleman we engaged in conversation, and a few minutes later he took off his cap and showed us a large fruiting body of *D. duplicata* in it. After some exclamations on my part he informed me that he used it in this manner to cure his rheumatism." I think I would rather keep the rheumatism or even follow the suggestions of Charles McIlvaine (18) who ended his discussion of *P. impudicus* with these two paragraphs.

"P. impudicus makes itself known wherever it grows. The stench of the full-grown plant is aggravatingly offensive, attracting blow-flies in quantities, and the carrion beetle Necrophorus Americanus. It is common over the United States, in woods, open fence corners, along roadsides, but a favorite abode is in kitchen yards and under wooden steps, where, when mature, it will compel the household to seek it in self-defense. It is a beautiful plant."

"When in the egg-shape it is white or light dull-green, semi-gelatinous, tenacious and elastic. As many as a dozen sometimes grow in a bunch, each from a peculiar white, cord-like root or mycelium. They look, when young, like bubbles of some thick substance. In this condition they are very good when fried. They demand to be eaten at this time, if at any." Perhaps I'll try one someday; at the very least, they are handsomer than limburger.

There is another major arrangement in the design of the fructification. The spongy character of the receptacle is much the same among members of this, the family Clathraceae, as with Phallaceae, but the whole structure is quite different in form and in the placement of the gleba. At one extreme are the "fungal flowers" of Australia (*Aseroë*) with broad stalks that are

flattened at the top, there laden with gleba. Attached to the edge of this fertile area like the incised petals of a scarlet flower are horizontal extensions of sterile tissue. A similar form (*Kalchbrennera*) exists in South America. In the United States specimens of the genus *Lysurus* have been collected in many temperate areas. The receptacle is mostly tall, pale stalk. A half-dozen short arms arch over the gleba, but later may spread outward.

The fetid lantern, *Clathrus,* is found in the southern United States, and is reputed to be poisonous (11). The receptacles are rosy red lattice-work expansions of spongy tissue shaped like inverted pears. The greenish gleba coats the *inside* of the lattice. Some of these are about three inches in breadth, and some are yellow (7). There is a stalked variation on the same theme (*Simblum*). The bulb at the top of the column is a tighter lattice, bearing the gleba on its inner surface.

Simpler and smaller forms (*Pseudocolus*) have occasionally been found farther northward than the Carolinas (Pennsylvania, Massachusetts) (11, 21). The red, hollow columnar receptacle is branched into three or more gleba-bearing arms that flair outward, but are joined at their tips. The base of the small column is subtended, as with all phalloid fungi, by the volva, the remnants of the skin of the egg.

Fig. 2. *Phallus Ravenelii*

The phalloid egg is an amazing package, and its hatching, a remarkable example of structural rearrangement. It happens in a few hours. The thrusting of the receptacle above the ground is ecologically similar to the growth of the mushroom stalk that hoists the spore-bearing portion into more turbulent air where the dry spores may be blown away. With the stinkhorn, it is the odor that goes, not the spores.

Inside the resilient skin of the mature egg of, say, *Mutinus caninus,* is a thick layer of watery jelly (Fig. 4). In the center is the hollow stalk of the receptacle, the cells of which are tightly compressed. The cavity of the stalk and the small chambers of the receptacular tissue are also filled with watery jelly. The gleba and subsidiary tissues lie between the stalk and the jelly layer next to the skin. They are fully grown; it is the receptacle that changes shape. Before hatching, the young fructification has both accumulated the water in the jelly and manufactured the cells of the receptacle. As hatching approaches, additional water moves into the living tissue of the stalk until the pressure overcomes the resistance of the skin, which ruptures.

Water continues to move into the stalk cells. The resultant increase in size and change in shape of these structural components result in the radical enlargement of the compartments of the entire column. Burt (9) has shown that the receptacle will elongate even if separated from the thick jelly layer, as the cells evidently utilize the moisture in the stalk cavity and expanding compartments next to the cells. Elongation is more rapid if the receptacle has access to water, however.

The unfolding and expansion of the receptacle is accompanied by rapid conversion of the complex carbohydrate, glycogen, to the simple sugar, glucose. Just what triggers this conversion that causes water to change its position in the little world inside the egg, and thereby change the shape of its various parts, is not known. Even casual observation, however, discloses that the egg is by no means impervious to light. Indeed, I have seen groups of eggs in the slanting autumn sunlight that seemed to glow. The pigments of the colorful stalks may play a functional role even inside the egg. The suggestion that light probably is important in promoting the conversion of glycogen to glucose in fungi was made years ago by Buller (8, pp. 320-321). Opportunities for further study of development in this group have too long been ignored, considering that some species occur in great abundance.

Then the Aphids

Far be it from a gardener or a farmer to say "Pity the poor aphid," but if the little beast be considered in the light of his own problems, the success of the group as a whole is fairly remarkable. In the first place, they are rather small and soft bodied. When at work on a leaf or stem they stand away from its surface on slender legs ready for grabbing. Furthermore, they are terrible runners, and even should they attempt a sprint start, instant disaster would befall. They would break off their mouths.

Fig. 3. Detail of *Phallus Ravenelii*

The aphids are sucking insects, with an apparatus used in obtaining nourishment from plants that is impressively designed. So also is the nervous system that regulates the performance of the apparatus. The structure is actually a bundle of four highly modified mouth parts. One pair serves as the binder for the other two, and probably also as a guidance system, because there is evidence of a slender nerve in each. The other, enclosed pair, consists of two slender tubules, open at the tip. Associated with the device are structures in the head, thought to be pumps and quality control meters (3).

The part that is inserted in the plant can be almost 1/16 inch long (ca. 1580 microns), but one of the usual types is about one-fifth of that (300 microns). The diameter of such a bundle is about 3 microns, but the bores of the two channels are even smaller. The forward one that actually collects the food is a half micron wide, with a narrower tip. Just behind it in the bundle is the still more slender saliva tube, the tip of which might be less than a tenth of a micron in diameter, (one two-hundred-fifty-thousandth of an inch).

Some aphids feed on the sap of soft cells close to the plant surface. A great many others get their food directly from the phloem conduits in the leaf veins. Imagine the task of such an aphid. It must select a site, begin probing for cells it cannot see, recognize them when it finds them, and prevent clogging of the food tube. Meantime at the surface, its soft body, trapped by its own proboscis, is unable to dodge danger quickly. The whole insertion process can take a good deal of time — on the order of half an hour — before the sweet liquid really begins to flow. And flow it does! As if to make up for lost time, the aphid can ingest about 50 per cent of its body weight in sap *per hour*. These insects have the ability to take up liquids that are not under pressure, so it is clear that they can regulate the flow of sap, but the rapid ingestion rates in nature result partly from the pressure in the cells of the plant. Aphids have been separated from their inserted mouth parts and the sap continues to exude through the tubule. This permits people to study not only flow rates mediated by the plant, but also the composition of the material moving through the plant's vascular system.

The rapid flow rate presents another set of problems to the aphid though. It must hastily process the material received, taking from it useful items, casting back into it unwanted metabolic products. About half the nitrogen is removed but, just as it entered the aphid, the processed sap consists mainly of a solution of sugars.

And then there is the enormous puzzle of getting rid of almost as much as is taken in. The aphid body has no storage facilities of such magnitude (no kidneys or Malpighian tubules, for that matter), and yet there it is, anchored in one place by its proboscis. The disposal problem must be handled adroitly because it is fraught with subtle dangers. The liquid, rich in carbohydrates, still containing some amino acids, is a fine culture medium for an ecologically specialized group of fungi, the sooty molds. These will grow wherever the sweet effluvium is, and if it should be on the body of the aphid, so also will they grow there, eventually clogging the anal valves and causing no end of trouble. How to dispose of the liquid "honey dew" ("manna")? Among the various species are a number of adaptations. One type relates to forming a dis-

crete droplet. Thus there may be wax secretors or hairs suitably arranged. Another type is associated with separating the droplet from the body. The structural adaptations of this sort are strong ejection mechanisms at the anal end of the digestive tract. There are important behavioral patterns as well. The aphids use the posterior pair of legs to kick the droplet away, and the members of a herd feed sufficiently distant from one another to avoid contamination from their fellows. Plant veins are most accessible on the lower surfaces of leaves. This is where the insects more frequently feed, hence gravity plays an important role in honey dew disposal.

The rain of honeydew is so often copious that sufficient quantities could be obtained for analysis even by early chemists. At least two sugars were first discovered in honey dew. One of them, incidentally, was trehaleose the principal sugar constituent of insect blood, and the only disaccharide formed in appreciable amounts by fungi (10). The plentiful food cast off by the aphid herds is used by more than a peculiar group of molds. There are about 250 species of honey dew-feeding insects alone! Not all of these insects are casual opportunists. Indeed certain of them together with certain aphids, have become so firmly associated with each other that they take care of one another. Lots of ants like honey dew.

And Then The Ants

The ants, ten thousand species of them, are an enormous batch of creatures. Our notion of their being irritable pests is only a fringe impression however, because they are most at home in the area of their origin, the tropics, where troops of one sort or another can walk off with stores of food overnight, with carcasses of large animals, with the foliage of whole gardens (5, 27). They are not insignificant. This *concerted* type of activity of thousands of beings is immediately impressive on the face of it, but its implications are of fundamental importance to our understanding of our world.

Ants are a combination of relative simplicity with elegant organization. The results of the organization could not fail to intrigue early investigators who learned a great deal about what ant societies do (27). For example, it has long been known that queen ants, who found and populate the colony, can live to great age (15-20 years), that many generations of offspring, living much shorter times (3-4 years), tend her and the young, and that a colony itself may become a dynasty lasting several decades. Detailed information accumulated about the anatomy of the ants, about the castes and their labors, and about their eating habits.

Certain aspects of ant to ant behavior were examined in some detail by Wheeler and his contemporaries (27). By feeding them colored sugar solutions, for instance, it was discovered that ants really can fill themselves with food which is later passed about among their nestmates. For a long time it was thought that ants conveyed information to one another mainly by feeling each other with antennae and forelegs or by rubbing certain specialized parts of their body together to make noises.

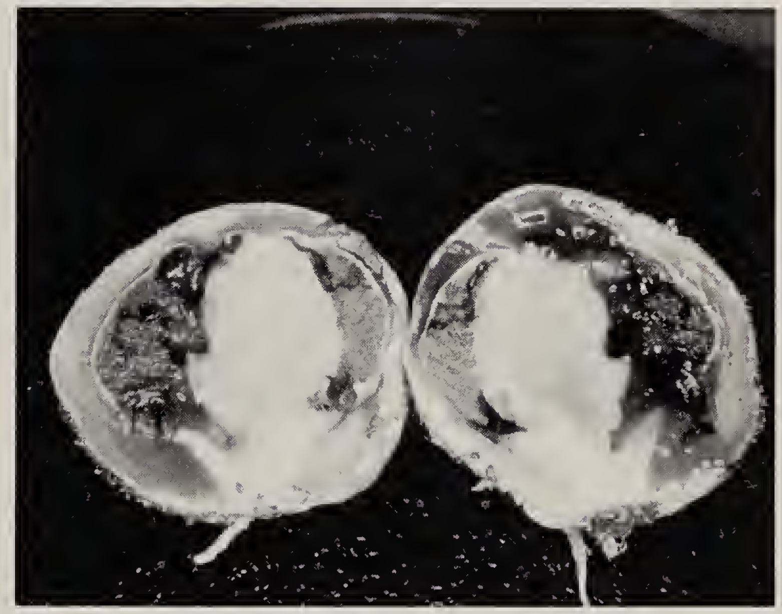

Fig. 4. Egg of *Mutinus caninus*

The ever-increasing body of literature about the individual and about the society has not changed our conviction that despite a physique enabling it to perceive acutely, to manipulate its body adeptly, and even to use tools, the ant is just not a giant of intellect (12). Although they are much more advanced than a lot of other insects, they still are "stimulus-bound reflex animals." Indeed, the social ants, the very type that has received such admiration, have simpler behavior patterns than those of many solitary insects. The fact that one so simple can be so social so successfully has motivated newer inquisitors with newer resources at their command (16, 26, 28, 29).

The use of radioisotopes instead of stained syrup, for example, has revealed that the liquid from the crop of a single worker becomes evenly distributed among a hundred or so more workers in less than 24 hours (28), but not to the queen and not to the brood. About the time the tracer shows up in certain mouth glands of the workers it begins to appear in the queen and larvae.

Fig. 5. *Prenolepis imparis* carrying off an aphid nymph.

Similarly, new anatomical studies coupled with modern behavior assay techniques and microchemistry have disclosed that there are numerous glands in the ant's body that form a variety of compounds (pheromones) which are perceptible to ants and affect either their nervous systems or their endocrine and reproductive systems. The former results in measurable changes in activity, such as alarm patterns, attraction, or exchange of food. The latter type evokes developmental alterations.

E. O. Wilson (29) discusses a remarkable forecast he and Dr. W. H. Bossert made. By integrating what already was known about pheromones, the limitations that the structure of the nervous system imposed on perception, and alarm signals in general, they were able to *predict* what type of compound the alarm pheromone would be as well as its molecular weight and the number of carbon atoms in its structure.

Other sorts of knowledge, as the quantity of pheromone released, its volatility, and the concentration necessary to evoke the response permit accurate deduction of how ants lay trails, how many individuals are necessary for persistent trail effectiveness, and thus how numbers of ants are related to food goals (28).

Even noise-making is being evaluated anew by modern electronic methods (17).

Thus the question has become not so much what the ants do but how they do it, to the end that information will be gathered about the basic problem of how creatures coordinate. The lowly ant promises to be just as valuable a research organism in an even broader area. This is that vast jungle of ignorance: inter-specific communication.

The primitive ants are predacious wanderers (27). The nesting habit, probably accompanied by the development of homing devices (16, 26), is thought to be an evolutionary step forward. It has, in any event, permitted the storage of materials by species that are basically predators or grazers. It has also resulted in the establishment of a highly desirable environment and the localization of waste products. Invasion of the nest by other organisms was inevitable. Mere propinquity (4, 22) may have accounted for the development of more and more specialized relationships between species. Anyway, certain species have become ecologically dependent on one another. Among such integrated societies are ants with other ants (usually closely related to one another), ants with aphids, and ants with fungi.

Ants and Aphids

Colonies of a given ant can be at various integrative levels with several aphid species at the same time (23), and members of a given aphid species may enjoy relations of a variety of levels of specialization with members of diverse ant species.

The most casual relationship is the mere harvesting of honey dew. Even this involves a few refinements. The ant rubs the aphid's abdomen with its antennae, and although this induces the extrusion of honey dew, it does not trigger forcible ejection of it. A side benefit for the aphid is the lessening of sooty mold contamination. At the other extreme is the single physiologically obligatory relationship known. In Europe the little pavement ant is sometimes saddled with a guest aphid (*Paracletus cimiformis*) that does not have a very good work record. The ant tends and transports the aphid, but the aphid (a root feeder) makes honey dew only part of the year. The rest of the time the ant doles out food to the aphid. The guest is dependent on the pavement ant for survival as a life form. Intermediate forms of integration involve herding of aphids to good feeding sites, transport of nymphs, providing of winter shelter, and tending of aphid broods in the ant nest (3, 23,) (Fig. 5).

An interesting aspect of the ant-aphid relationship is the influence of the ant on the aphid individuals. They feed more and grow faster and larger. An even more interesting aspect is the effect of the ant on the aphid population. Attended aphids produce more young while being attended. This, in addition to brood tending and the induction of sexual forms, sometimes

elevates the aphid population. Most ants, on the other hand, are predators as well as scavengers, and although honey dew is extremely important, ants do utilize meat. The meat is occasionally the aphid. These victims might be collected above ground then brought to the nest for consumption by the queen or larvae. (Most adult workers utilize only liquid diets and may then get a nitrogen boost second-hand from the queen or larvae.) Or they might be taken from the aphid larvae being sheltered below ground. These activities, of course, restrict the population.

All sorts of inter-specific combinations can be in full swing in a small area. I must confess that I was impressed with Wheeler's report (27) that he found at the Arnold Arboretum an association in the ground of ants (*Lasius* spp.), aphids, mealy bugs, mites, and woody plant roots until I remembered I had often seen aphids associated with the roots of certain weeds in my garden. A short stroll to a specimen of *Plantago lanceolata* and a tug brought to light *Lasius niger americanus, Solenopsis molesta* (an extraordinarily small ant that preys on the brood of others), a root-feeding aphid, many large grubs of which the *Lasius* ants were ardently fond, and innumerable other dashing creatures.

Ants and Fungi

Numerous ants like fungi, and among the most interesting and baffling societies of all are those involving a group of ants that in nature are apparently nutritionally dependent upon the fungus they actually cultivate. The fungus also

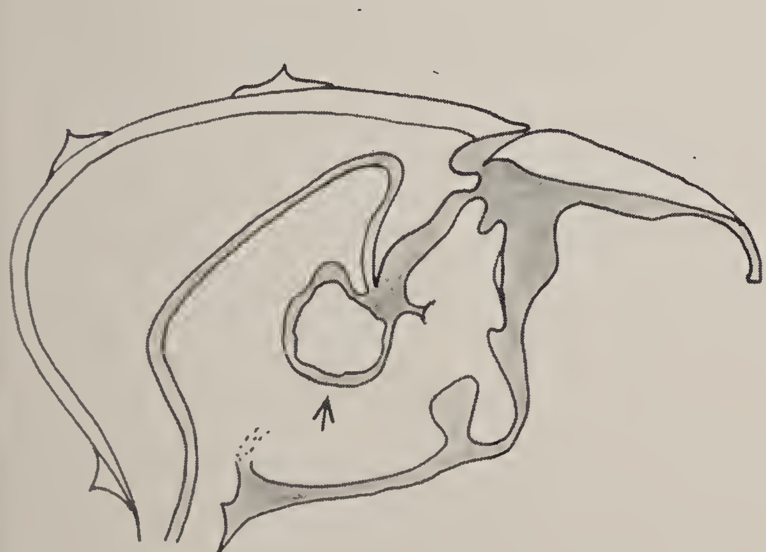

Fig. 6. Diagram of a section of the head of a fungus-culturing ant, showing infrabuccal pouch near the opening to the esophagus. Redrawn after Weber (25).

Fig. 7. *Prenolepis imparis* cutting bits of *Mutinus caninus* receptacle.

seems always to be associated with ants in nature. Other relationships exist that probably are on only the grazing level or the sheltering level. The latter would include those combinations in which ants consume fungi which happen to grow on their nest trash (4).

All of the ants that cultivate fungi in special chambers in their nests are closely related new world ants. Most of them are tropical, but one lives nearby in New Jersey and New York (24). The ants must overcome several obstacles to fungus culture. It must find, harvest, and bring to the nest raw materials for the fungus culture medium. This activity results in enormous losses to tropical agriculture. Hordes of ants, so numerous and so busy, can stamp broad pathways in the soil between their nests and the foliage that they gather and transport fragment by fragment (1, 5, 6, 25). The leaves are made into a suitable substrate by further division, licking, pummeling, and the addition of feces.

The species of plant harvested does not seem to be critical. The Texas Leaf-Cutting Ant, *Atta texana,* for example, damages a wide variety of crops. What is important is the way the ant maintains the purity of the culture in an environment so favorable to other microorganisms. That the fungus alone does not achieve it by antibiotic means becomes evident as soon as the tending ants are removed from a fungus garden. The valuable crop is overwhelmed by weed species. The keepers achieve the virtual monoculture by weeding and toxin production.

Another obstacle is the starting of the new colony culture. When the virgin queen goes aloft on her nuptial flight she carries the fungus with her in a little pouch near the opening to her esophagus (Fig. 6, arrow).

The student of the fungus-ant society is still faced with problems relating to the fungus. The development of suitable techniques for the maintenance of captive colonies has helped a great deal. Obtaining certain of the fungi in pure culture on artificial media has helped even more. This achievement permits the ridding of the fungus of ant pheromones that would be repulsive to other ants. Thus the abilities of various ant species to grow the same fungus can be examined (25). Methods of inducing fructification of the fungi in culture are also yielding valuable information about the interesting interspecific relationship. Most of the few fungi so far identified are Basidiomycetes.

Ants, Aphids, and Stinkhorns

There may be still another relationship between ants and the fungi involving more specialized fungal dispersal than mere chance transport (Fig. 7). That such relationships between insects and fungi exist is well known, as between, for example, the Dutch Elm Disease pathogen and bark beetles. Ants seem especially attracted to certain stinkhorns. *Mutinus caninus* is one of them. The little aphid-transporting ant, *Prenolepis imparis* apparently is fond of *M. caninus* and has been observed not only lapping up spores, but biting off and carrying away portions of the colorful receptacle as well (2).

Acknowledgement

Professor Neal A. Weber of Swarthmore College has been especially kind during the preparation of this article, not only by identifying several species of ant but by extending the hospitality of his laboratory to the author.

Literature Cited

1. Allison, Patricia. 1964. A Mycologist in Ecuador. Morris Arb. Bull. 15: 3-14.
2. ———————. 1969. The Possible role of Prenolepis imparis Say in the dispersal of Mutinus caninus. Morris Arb. Bull. 20: in press.
3. Auclair, Jacques L. 1963. Aphid feeding and nutrition. Ann. Rev. Ent. 8: 439-490.
4. Bailey, Irving W. 1920. Some relations between ants and fungi. Ecology 1: 174-189.
5. Bates, Henry Walter. 1962. The Naturalist on the River Amazons. The Univ. of Calif. Press, Berkeley. 465 pp. (Reprinted from the 2nd ed., John Murray, London, 1864.)
6. Bennett, William H. 1967. The Texas leaf-cutting ant. U. S. D. A. Forest Pest Leaflet 23. 1-4.
7. Bessey, Ernst Athearn. 1950-2. Morphology and Taxonomy of Fungi. Blakiston, Philadelphia. 791 pp.
8. Buller, A. H. R. 1922. Researches of Fungi vol. II. Longmans, Green, London, 492 pp.
9. Burt, Edward A. 1897. Phalloideae of the United States III. On the physiology of elongation of the receptaculum. Botan. Gaz. XXIV: 73-92.
10. Cochrane, Vincent W. 1958. Physiology of Fungi. John Wiley & Sons, Inc., New York. 524 pp.
11. Coker, W. C. and J. N. Couch. 1928. The Gasteromycetes of the Eastern United States and Canada. Chapel Hill, N. C., Univ. of N. C. Press. 201 pp.
12. Dethier, V. G. and Eliot Stellar. 1961. Animal Behavior. Prentice-Hall, Englewood Cliffs, N. J., 118 pp.
13. Gäumann, Ernst Albert, and Frederick Lyle Wynd. 1952. The Fungi. Hafner, New York. 422 pp.
14. Ingold, C. T. 1953, 1964. Dispersal in Fungi. Clarendon Press, Oxford. 208 pp.
15. ———————. 1965. Spore Liberation. Clarendon Press, Oxford. 210 pp.
16. Jander, Rudolph. 1963. Insect Orientation. Ann. Rev. Ent. 8: 95-114.
17. Markl, Hubert. 1965. Stridulation in leaf-cutting ants. Science. 149: 1392-1393.
18. McIlvaine, Charles, and Robert K. McAdam. 1900. One thousand American fungi. Bowen, Merrill, Indianapolis. 704 pp.
19. Savile, D. B. O. 1968. Possible interrelationships between fungal groups. *in* The Fungi, vol. III. Academic Press, New York. 649-675.
20. Smith, Alexander H. 1951. Puffballs and their allies in Michigan. Univ. Mich. Press, Ann Arbor. 131 pp.
21. Snell, Walter H., and Esther A. Dick. 1956. An unusual Phalloid from Massachusetts. Mycologia. 48: 327.
22. Wallace, Bruce, and Adrian Srb. 1961. Adaptation. Prentice-Hall, Englewood Cliffs, N. J. 113 pp.
23. Way, N. J. 1963. Mutualism between ants and honey dew-producing Homoptera. Ann. Rev. Ent. 8: 307-344.
24. Weber, Neal A. 1956. Fungus-growing ants and their fungi: *Trachymyrmex septentrionalis*. Ecology 37: 150-161.
25. ———————. 1966. Fungus-growing ants. Science. 153: 587-604.
26. Wehner, Rudiger, and Randolf Menzel. 1969. Homing in the ant Calaglyphis bicolor. Science. 164: 192-194.
27. Wheeler, William Morton. 1923. Social life among the insects. Harcourt Brace and Co., New York. 367 pp.
28. Wilson, Edward O. 1963. The Social biology of ants. Ann. Rev. Ent. 8: 345-368.
29. ———————. 1965. Chemical communication in the social insects. Science. 149: 1064-1071.

Book Review

Ornamental Shrubs for Canada. By Lawrence C. Sherk and Arthur R. Buckley. Ottawa, Ontario, Research Branch, Canada Department of Agriculture, 1968. $3.00.

This well-printed volume is deceptively compact. It embraces an impressively large array of woody plant materials which can be grown in suitable localities occurring within the vast climatic range of Canada's nearly four million square miles.

The authors have performed a valuable service in having organized informative comment on an extensive selection of shrubs which reflects their own long-term experiences as well as those of such devoted horticulturists as Miss Isabella Preston, horticulturists at Morden and Dropmore, et al. Indeed, it seems quite appropriate that the book includes a graceful dedication to the late Miss Preston who worked significantly and successfully for many years in the production of interesting, cold-resistant hybrids and selections of such widely separated genera as *Lilium, Syringa,* and *Iris.*

The work includes twelve sections covering the following topics: Planting, Pruning, Diseases, Insect Pests, Pesticides, and classified lists of shrubs suitable for specific purposes. The major portion of the book is devoted to brief, original descriptions of recommended taxa representing over 180 genera arranged alphabetically according to genus. The authors state, in a number of cases, that nomenclature has been checked with the forthcoming taxonomic treatment to be published in *Hortus Third*. For example, some readers will be interested to find the old favorite *Magnolia stellata* listed as *M. kobus stellata.* Wherever possible, common names are included.

The description of *Weigela* 'Newport Red' as being synonymous with *W.* 'Vanicek' (or 'Vaniceki') does not agree with the reviewer's experience with these two cultivars. *W.* 'Newport Red' is a markedly more robust plant, amenable to being trained as a standard, with larger blossoms of more rosy red cast than those of *W.* 'Vaniceki' which has more of the dark red tone seen in *W.* 'Bristol Ruby' and *W.* 'Eva Rathke'. There are differences in foliage as well.

The description given for the "Double Bridalwreath Spiraea" should be designated as applying to *Spiraea prunifolia* Sieb. & Zucc. *plena* Schneid. which form appears to be the type of the species. The inclusion of *Prunus laurocerasus, Camellia japonica,* and *Laurus nobilis* in contrast to *Amelanchier alnifolia* and *Caragana arborescens* will merely emphasize the moderate climate of British Columbia in comparison with, e.g., the rigorous, mid-continental climate of of northern Manitoba.

Helpful fold-out maps depicting Canadian plant hardiness zones are illustrated by indicator plants which normally survive and grow in the designated areas. Any serious gardener will find this publication a highly useful volume for his library. There are many illustrations of which a number are published in color. An excellent photograph portrays well the superior character of the less than well-known cultivar 'Annabelle' of *Hydrangea arborescens.* At its modest price, the publication is an astonishing bargain. The book is available by mail from the Queen's Printer, Ottawa.

A. Orville Dahl

Arboretum Activities

(Continued from page 50)

In formulating our schedules for 1969, we have designated Friday, May 23 (9 a.m. to 4 p.m.) and Saturday, May 24 (10 a.m. to noon) as the 1969 Plant Distribution Days for the Associates of the Morris Arboretum. Some six to ten choice cultivars are being readied for selection on the two distribution days. The distribution takes place at the Gates Hall (Administration) entrance on Meadowbrook Avenue.

The Staff

Dr. Li has been involved in research preparations for his leave of absence during the spring semester, 1969. His joint project with *Dr. J. J. Willaman* on Alkaloid Plants, which is sponsored by the National Institutes of Health, is approaching completion.

On October 7th, *Dr. Allison* presented a lecture on Fungi to the Wissahickon Garden Club.

(Continued on page 62)

Visitors to the Morris Arboretum

During the past year, we have had the pleasure of welcoming many visitors to the Arboretum. Visitors signing our Guest Book include:

Dr. Andre Robyns, Jardin Botanique, Bruxelles, Belgium

Dr. Andrei M. Grodzinsky, Kiev Central Botanical Garden, USSR

Mrs. M. N. Philipson, Botany Div., D.S.I.R. Christchurch, New Zealand

Mrs. Gladys Crozier, Christchurch, New Zealand

Mary K. Moulton, Morton Arboretum, Lisle, Illinois

Dr. and Mrs. Robert Jenness, University of Minnesota, St. Paul, Minn.

Dr. Frans A. Stafleu, Utrecht, Netherlands

Dr. William J. Robbins, Rockfeller University, New York, N. Y.

Dr. Joseph Ewan, Tulane University, New Orleans, La.

Dr. Richard W. Lighty, University of Delaware, Newark, Del.

Dr. Ta-wei Hu, Forestry Res. Institute, Taipei, Taiwan, Republic of China

Dr. Philip J. Jew, Auckland Regional Authority, Auckland, New Zealand

Dr. Theodore Eckhardt, Director Berlin Botanical Garden, Berlin, Germany

Dr. Lloyd Spetzman, U.S.D.A. Beltsville, Maryland

Dr. Robert Perdue, U.S.D.A. Beltsville, Maryland

Dr. H. Heine, Lab. de Phanerogamme, Museum d'Histoire Naturelle, Paris, France

Library Accessions

A Glossary of Genetics and Cytogenetics. R. Rieger, A. Michaelis and M. M. Green. Springer Verlag. New York. 1968.

An Annotated Index of Plant Diseases in Canada. I. L. Conners. Canadian Dept. Agr. 1967.

An Enumeration of Philippine Flowering Plants. Elmer D. Merrill. Vols. I, II, III, IV. Bureau of Sci. Manila. Reprint A. Asher & Co. Amsterdam. 1968.

Bulbs & Perennials. E. Richmond and Charles R. Harrison. A. H. & A. W. Reed. Wellington, N. Z. 1967.

*Diseases in Forest Plantations. Don V. Baxter. Cranbrook Inst. of Sci. Bloomfield Hills, Mich. 1967.

Enumeratio Plantarum Javae. C. L. Blume. A. Asher & Co. Amsterdam, Netherlands. 1968.

Families of Flowering Plants in Ethiopia. Wm. C. Burger. Oklahoma State Univ. Press. 1967.

Ferns. Robert H. Mohlenbrock. So. Ill. Univ. Press. Carbondale. 1967.

Field Guide to the Alpine Plants of New Zealand. John T. Salmon. A. H. & A. W. Reed. Wellington, N. Z. 1968.

**Garden Open Today. Beverly Nichols. E. P. Dutton & Co. New York. 1963.

Mycological Studies Honoring John N. Couch. edited by Wm. F. Koch. Univ. N. C. Press. Chapel Hill. 1968.

New Zealand Plants and Their Story. L. Cockayne. R. E. Owne, Govt. Printer. Wellington, N. Z. 1967.

One Hundred Best Trees & Shrubs, J. W. & Barbara Matthews. Duncan & Davies, Ltd. New Plymouth, New Zealand.

Papers on Plant Systematics. Selected by Robert Ornduff. Little, Brown & Co. Boston. 1967.

***Plant Life. Vol. 6. 1950. The American Plant Life Soc. Stanford, Calif. 1950.

Plant Propagation. Principles and Practices. Hudson T. Hortman & Dale E. Kester. Prentice-Hall Inc. Englewood Cliffs, N. J. 1965.

Prairie Plants and Their Environment. J. E. Weaver. Univ. Nebraska Press. 1968.

***Shrubs in Color. A. G. L. Hellyer. Doubleday & Co., Inc. Garden City, N. Y. 1966.

Systematic Embryology of the Angiosperms. Gwenda L. Davis. John Wiley & Sons. N. Y. 1966.

The Bee Man. Life and Letters of Everett Franklin Phillips. Mary Geisler Phillips. Cornell Univ. Ithaca, N. Y. 1967.

The Genus Septobasidium. John N. Couch. Univ. North Carolina Press. 1938.

The Mushroom Handbook. Louis C. Krieger. Dover Publications. N. Y. 1967.

The New Story of the Kauri. A. H. Reed & Contributors. A. H. and A. W. Reed. Wellington, New Zealand. 1968.

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* Gift of the Publisher
** Gift of Mrs. Virginia Thomas
***Gift of Dr. Edgar T. Wherry

Note on the European Pavement Ant, Tetramorium caespitum, in the Philadelphia area (Hymenoptera: Formicidae)[1]

NEAL A. WEBER
Swarthmore College, Swarthmore, Pennsylvania

Fig. 1. Parrish Hall, Swarthmore College

The Philadelphia, Pennsylvania, area may have been one of the original sites of introduction of the common European pavement ant, *Tetramorium caespitum* L., into the United States. Sailing ships from Europe, since the days of William Penn in the 17th Century, may have brought this species with cargo. The Swedes, Dutch, and British could have brought colonies repeatedly to the mild shores of the Delaware River at Marcus Hook, Upland (now Chester), and later to Philadelphia. This may be the species referred to by Kalm in 1748 in Philadelphia (Donisthorpe, 1927). A more specific and more recent manner of carrying the ants is suggested by the repeated introduction of English ivy (*Hedera helix*) to the campus of Swarthmore College in the southwestern suburban area of Philadelphia. An historical account of the acquisition of the ivy covering the walls of the principal college building, Parrish Hall, has been recently given by Isabelle Bronk (1964) (Fig. 1). This account, originally published in 1908, states that the custom of setting out class ivies was inaugurated in 1889. Members of the college were accustomed to bring living slips of ivy from Europe, before the days of the U. S. Department of Agriculture Plant Quarantine Service. It would have been a simple matter for a fecundated female of this ant to have survived the journey in soil about the ivy roots. For example, Dean Bond brought some in 1903 from the ruins of Ludlow Castle, England, others brought living

[1] Reprinted, with permission of the author, from ENTOMOLOGICAL NEWS, Vol. LXXVI, No. 5, May, 1965. Photo courtesy of Swarthmore College.

ivy from a Quaker meeting house at Swarthmore, England, from Addisons' Walk at Magdalen College, Oxford, from Christ's College, Cambridge, from a ruined church in Scotland, and from the Royal Gardens of the Luxembourg, Paris.

This ant is well established on the Swarthmore College campus at the present time and is abundant under the walls and walks about Parrish Hall. It lives also in and about the Benjamin West House on the campus, the house where the celebrated painter was born in 1738. The house itself was built about 1724. The ants are here nocturnal during the winter months and scavenge over the ground floor for food, being warmed by basement heating pipes. In April and May workers appear regularly in large numbers on the pavement stones outside. They appear at the same time outside Parrish Hall and other buildings, emerging from under pavement stones. A room of the two-year-old Animal Wing of the biology building became infested with this species in October 1964.

These swarms engage in the well-known combats described by H. C. McCook (1878, 1879). His accounts and specific determinations leave no doubt that the habits of this ant have not changed in the approximate 100 years since he returned from participation in the Civil War to become a minister in Philadelphia. Ironically, the chief notoriety of these ants "is due to their martial instincts. Hundreds, even thousands of them are often seen waging battle with great ferocity and persistence. One battle, which was noted close by the wall, within the enclosure of a church on Broad Street and Penn Square, was prolonged for a period of two weeks and several days. . ." The combats that he described as taking place in May, 1879, occur regularly on the Swarthmore campus in the same month. They may take place as early as late April and may extend into June. Forel, quoted by Donisthorpe (*loc. cit.*), described an extended combat between thousands of ants that took place on the grounds of the University of Zurich, starting April 24, 1870, and lasting more than a month.

A modern study of this unusual and recurrent type of behavior would appear to be worthwhile, since no one has really explored the reasons for these conflicts. A possible hypothesis is that adjacent colonies increase in size until their territories meet or overlap. This expansion and increased seasonal activity results then in fighting.

Literature Cited

Bronk, I. 1964. Swarthmore College Bull. 61 (4): 18-20, Swarthmore, Pa.

Donisthorpe, H. 1927. British Ants, Geo. Routledge and Sons, London, xv + 436 pp.

McCook, H. C. 1878. Proc. Acad. Nat. Sc., Phila., pp. 15-19.

————. 1879. Proc. Acad. Nat. Sc., Phila., pp. 156-161.

Arboretum Activities

(*Continued from page 59*)

On October 10th, the Director attended a Biosatellite Research Conference, sponsored by the National Aeronautical and Space Administration at the University of Minnesota. He represented the Arboretum at the formal premiere showing of the excellent new film "The National Arboretum", at a ceremony honoring Senator Carl Hayden held at the United States National Arboretum in Washington on October 23rd. *Dr. Dahl* presented an illustrated lecture on "Cultivated Plants" before the Germantown Horticultural Society at their meeting on November 5th. He attended the first Holly Seminar sponsored by the Henry Foundation in Gladwyne on November 30th. The Director is serving on the local committee appointed to establish final arrangements for the coming 24th American Horticultural Congress to be held in Philadelphia, September 17th through the 19th, 1969. A Pre-Congress tour to the Morris Arboretum is planned for September 16, 1969.

We are pleased to welcome a new publication entitled "Newsletter of the Arboretum of the Barnes Foundation" with Dr. J. M. Fogg, Jr. the Director of the Arboretum of the Barnes Foundation as its Editor. We wish them success in their new enterprise.

A. Orville Dahl

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Morris Arboretum Bulletin

LEGES SINE MORIBUS VANAE

MARCH, 1969

VOL. 20 NUMBER 1

Juniperus conferta, the Shore Juniper, covers miles of coastline of Japan as solid mats. This stretch is along the cold Pacific side of northern Honshu. (U. S. D. A. Photo.)

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THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Arboretum.

CLASSES OF MEMBERSHIP

Sustaining .... $10.00 a year	Sponsoring .... $100.00 a year
Supporting .... $25.00 a year	Donor $500.00

Dedication

Fig. 1. Beside the Rose Garden, 1960.

This issue of the Bulletin of the Morris Arboretum is dedicated to the memory of Joseph Costanza who died January 11, 1969 at the age of 87.

Mr. Costanza came to the infant Arboretum as a boy in 1901, and left it, only a few weeks before his death, a man who had filled his lifetime with the toil he loved best. Behind he leaves a mature garden, much of whose beauty was tended by his hand.

Dr. E. Lucy Braun, renowned plant ecologist, wrote some lovely lines in 1950 about the seasons' cycle.[1] These we present here:

"A cycle has no end and no beginning. The cold of winter induces dormancy in many of our plants; life processes are slowed down; the deciduous forest 'sleeps.' The trees are leafless. The branch and twig arrangement and form and the bark contour and color dominate the forest aspect. Here and there are trees on which a few brown and lifeless leaves cling, but mostly the leaves of summer are now transferred to the forest floor, where the leaf litter protects from sudden temperature changes the root environment of all the forest plants and the living quarters of thousands of unseen inhabitants. Days are short. The sun is low in the southern skies and shadows are long. Sun reaches much of the forest floor, except on northerly slopes, accentuating the rapidity of diurnal temperature changes, of thawing after the cold of night. Snow lies on north slopes long after it has melted away from warmer slopes. The leaves of even the hardiest herbaceous plants suffer from too rapid thawing in sun after a freezing night; hence the winter woods displays, in its ground-layer, some differing slope aspects. Herbaceous plants which retain their leaves in winter, as *Hepatica, Hydrophyllum, Tiarella,* are often localized on northerly slopes where diurnal temperature changes are slow. The green leaves of these plants and the semi-evergreen leaves of such plants as *Smilax hispida* stand out conspicuously in the brown and gray background of the winter woods.

"The length of day increases; temperatures moderate; new growth starts. From beneath the protecting carpet of leaves on the forest floor,

[1] From "Deciduous Forests of Eastern North America" by E. Lucy Braun. Copyright 1950, The Blakiston Company. Used with permission of McGraw-Hill Book Company.

the first green shoots of the pre-vernal flora appear. From buds on subterranean parts, buds well formed during the previous warm season, growth is rapid. Earliest spring may find the ground carpeted with flowers while yet there is no sign of green on the trees. But the buds are swelling; flowers appear on elm, on poplar, on soft maple, changing the color of the forest canopy to richer though subdued tones of brown and red or dotting it with spots of crimson where red maple is a forest inhabitant. Buckeye leaves unfold; soft greens appear on many trees, or delicate reds where young leaves (as of white oak) are strongly colored.

"The vernal aspect prevails. Renewed growth is everywhere apparent. The trees are leafing; the forest floor is lightly shaded. The riot of brightly colored spring flowers, the vernal flora of our deciduous woods, appears. But not equally in all types. Many of the amentiferous trees are flowering; oak pollen dusts the dry leaves of the forest floor. In rapid sequence, the growth of buds and the flowering of different trees take place. The soft multicolor tones of early spring give way to various shades of green of later spring, with here and there the blossoms of some of the showy and conspicuous of the later blooming trees — the tuliptree, magnolias, chestnut and sourwood. The woods are shady now; the sun-loving species of earliest spring have almost completed their growth period and are ripening their seeds. Bright colored spring flowers are still present, for leaf growth is not yet complete and its shade not so dense as later.

"Soon the uniform green of summer prevails, the 'summer green' which has given this forest one of its names. In all the denser forests, light is insufficient for most showy flowers; the delicate leaves of ferns, which did not begin to uncurl until shade was developing, have reached maturity. Green is the prevailing color, in canopy and in undergrowth. Buds are forming, on tree, on shrub, on herb — buds which will rest during the long dormant season, but which will be ready for the rapid growth of the next season. Flowering and, in many species, fruiting are completed; buds are full grown; life processes slow down. The absciss-layer is slowly forming, cutting down the water and nutrient supply to the leaves. Chemical changes set in; the green of summer changes and yellows and reds begin to appear.

"The autumnal aspect of the American deciduous forest is a glorious sight, not shared by her European counterpart, although it is by the forest of eastern Asia. The innumerable brilliantly colored species of the American deciduous forest give to that forest one of its outstanding characteristics.

"Leaf fall is in progress. Some species early, some later, take on the leafless aspect of winter. The cycle of the seasons is completed."

The ARS-Longwood Plant Exploration Program in Woody Plant Improvement

by

JOHN L. CREECH[1]

The remarkable achievements of American plant breeders in crop improvement are due partly to the availability of a broad base of germ plasm and to the way these resources have been used, documented, and conserved. Plant introduction specialists have used the screening data provided by individual plant breeders to identify additional localities where collecting would be most rewarding. Even though there is exceptional genetic diversity in existing collections, as compared to the situation prior to World War II, the need to screen plant introductions and to make additional collections continues.

[1] Chief, New Crops Research Branch, U. S. Department of Agriculture, Agricultural Research Service, Crops Research Division, Beltsville, Maryland 20705. Photos courtesy of U. S. Department of Agriculture.

The centers of diversity for crop plant progenitors are fairly well known, and even subcenters have been identified for specific traits. While we have the same basic information on the origins of our garden plants, much of the early collecting was limited to sampling, without opportunity to consider the total distribution of the species. With a wealth of information from explorers' records as background, the Agricultural Research Service-Longwood Plant Exploration Program, initiated in 1956, allowed us the opportunity to conduct sustained ornamental plant exploration. For the first time, we were able to give attention to the diversity that exists in our introduced ornamental species.

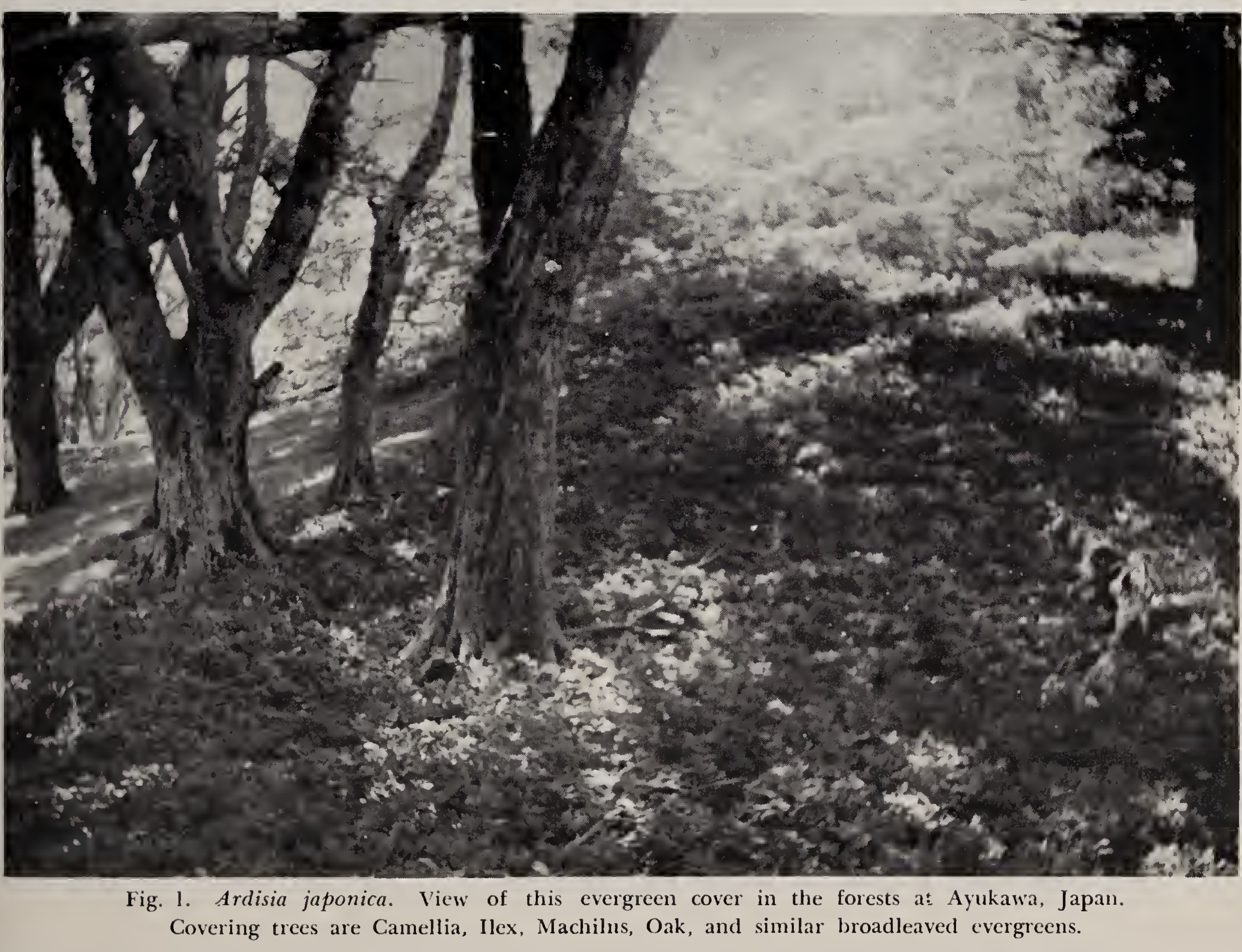

Fig. 1. *Ardisia japonica.* View of this evergreen cover in the forests at Ayukawa, Japan. Covering trees are Camellia, Ilex, Machilus, Oak, and similar broadleaved evergreens.

Fig. 2. *Rhododendron rubropilosum* on open slopes to Mt. Morrison, Taiwan. This evergreen azalea is not unlike *R. kiusianum* (*R. obtusum* f. *japonicum*) of Japan in habit and colonizing behavior.

Under the ARS-Longwood program, 11 explorations have been completed. Some have emphasized the centers of origins of woody plants. Since the Orient is one of the richest sources of plants for American gardens, our collecting expeditions have been sent to Japan, Korea, Ryukyu Islands, Taiwan, and Nepal-Sikkim. Next year we will include New Guinea, where there are 155 endemic *Rhododendron* species.

Even these efforts have not been complete in relation to population principles based on studies conducted with native American species. A full complement of geographic types of each introduced ornamental is needed before we can fully appreciate the behavior of such plants.

The evidence available long before the ARS-Longwood program suggests that there are distinct advantages to sampling wild populations with these principles in mind. When Edgar Anderson went to the Balkans to collect plants from cold climates for the Arnold Arboretum in 1934, he gathered seed of a privet (*Ligustrum vulgare*) in the dry, barren hills near Sarajevo, Yugoslavia. The seed was sent to the USDA and assigned P.I. No. 107630. After only two years, observers in Wyoming and South Dakota reported on the outstanding hardiness of this privet. It has continued to excel in comparison to the Amur River North privet and consequently was named 'Cheyenne' by the USDA in 1965. Here is a case where the collector deliberately selected his material from an area with a severe climate and subsequent trials validated the concept.

In my own travels in Japan, I have seen hardiness trials conducted with the Japanese red pine (*Pinus densiflora*) in Hokkaido, to determine the relative hardiness of geographic races. This pine grows only as far north as the middle of Honshu. Seedlings collected at Mt. Hayachine, the northern limit of natural distribution, were markedly hardier and more vigorous in Hokkaido than progenies obtained from the milder climates of Kyushu and Shikoku.

We have frequently attempted this method of collecting in our ARS-Longwood program, particularly in Japan where it is easy to follow the entire distribution of a species. *Ardisia japonica,*

an evergreen ground cover, is reputedly hardy only in the mildest parts of the southern States (Fig. 1). It has been cultivated in Western gardens since 1830 either as a greenhouse plant or restricted to warm areas outdoors. Seedlings were gathered from the northern limit of distribution, along the Pacific coast of Honshu near Ayukawa, where the winter is especially cold and dry. These have thrived in the Washington, D.C. metropolitan area. But collections from the mild climate of Kyushu were winter-killed.

Azaleas, particularly the species of the section *Tsutsutsi* and those of the section *Pentanthera* native to the Orient, are among the garden plants with which the principles of population genetics and heterosis can be employed to advantage. These azaleas have their center of diversity in southern Japan and occur throughout Japan, parts of the China mainland, Korea, and Taiwan. Most of the species are very local in distribution but a few extend over thousands of miles.

The azaleas, *Rhododendron molle* and *R. japonicum,* form a pattern of continuous distribution from Hupei Province, China, to Mt. Hakkoda in northern Honshu, Japan. *R. molle,* found only in China, is distinguished from its Japanese relative by the uniformly golden-yellow flowers and the softly pubescent leaves. *R. japonicum* grows in Japan from southern Kyushu to the northern tip of Honshu. It is characterized by flowers, mostly orange-red, and glabrous leaves, except for hairs on the under-surface veins. However, at its southernmost distribution in Kyushu, the populations of *R. japonicum* include a large proportion of yellow-flowered plants. Occasional yellow flowers appear in lower

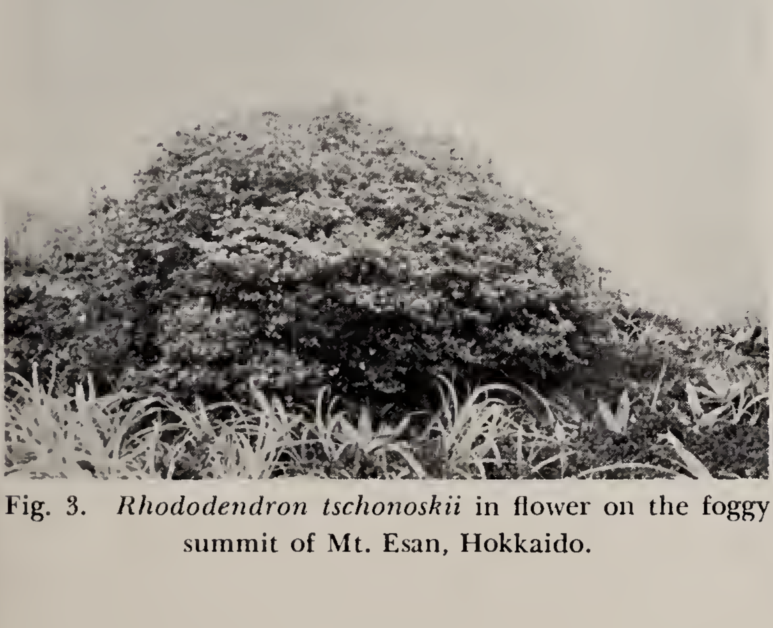

Fig. 3. *Rhododendron tschonoskii* in flower on the foggy summit of Mt. Esan, Hokkaido.

Fig. 4. Habitat of *Rhododendron kaempferi,* among lava blocks on Sakurajima, Kyushu.

Honshu while the colonies at Mt. Hakkoda have uniformly orange-red flowers. Disregarding specific designations, there is an indication that yellow flower color occurs only in the milder parts of the total distribution of *R. molle* and *R. japonicum.* We are searching for hardier forms, plants adapted to the hot summers of the South, and the possibility of developing pure color lines to avoid difficult vegetative propagation. The existence of this range of variability in nature offers exciting possibilities.

Similar conditions exist among the evergreen (*Tsutsutsi*) azaleas since we are dealing with more than 30 species with extremely varied distribution. Many of these azaleas occupy similar ecological sites in widely separated geographical regions. Thus we can find homologous species in the alpine zone of China, Taiwan, and Japan. *R. rubropilosum* (Taiwan) (Fig. 2), *R. kiusianum* (Kyushu), and *R. tschonoskii* (Hokkaido and Korea) (Fig. 3) all frequent alpine zones. Hybrids with these species as parents might result in cumulative hardiness.

Rhododendron kaempferi, one of the few azaleas with a significantly broad distribution, ranges from subtropical rice paddies in Kyushu to the moors of Hokkaido. During our 1961 ARS-Longwood exploration to Japan, I tried to collect this azalea as widely as possible to study the response of the geographic forms to our climate. In southern Japan, *R. kaempferi* is abundant on the slopes of the active volcano, Sakurajima, where it invades the crusted lava flows up to 1,500 meters (Fig. 4). Around Mt. Kirishima, it grows as close to the hot sulfur beds as the heat will permit. Throughout most of its distribution, *R. kaempferi* is a sun-loving plant. In central Honshu, however, it occurs mostly in the thin woods at the edges of fields, often mixed with *R. japonicum.*

Fig. 5. Collecting plants of *Rhododendron kaempferi* and natural hybrid seedlings along the roadside near Hamamatsu, Japan.

The flowers of *R. kaempferi* are uniformly red, grow in large clusters, and bear 5 stamens. Only once have I seen a white form that had been collected in the wild. On another occasion, I encountered a plant with ragged hose-in-hose flowers. In many places, *R. kaempferi* hybridizes naturally with associated species, including *R. macrosepalum, R. kiusianum, R. mucronatum,* and *R. komiyamae.* I have seen some of these hybrid swarms in the field, and it is not difficult to identify them. In these, the stamens vary between 5 and 10 and show other intermediate traits affecting calyx lobe shape and hairiness of the leaves and stems.

Rhododendron kaempferi reaches its distributional limit in central Hokkaido, where it grows in open moors and along the stream beds and blooms in early July. It exceeds the range of *R. japonicum,* which does not occur north of Honshu. This suggests that Kaempfer's azalea should be hardier. Our *R. kaempferi* collections from 23 different stations represent most of this variation. This information should be useful in future breeding programs where hardiness is an objective (Fig. 5). To my knowledge, azalea breeding in the United States, involving this azalea, has always relied on plants collected in botanic gardens. These plants have been of obscure origin. For the future, precise knowledge of the origin of the parent species will be important if we are to improve present-day varieties.

The foregoing remarks suggest the many possibilities for employing the natural variation in ornamental species to improve our garden plants. China and Japan are replete with plants growing under vastly different environments. One may find interesting distributions in *Ilex crenata* (Fig. 6, 7), *Camellia japonica, Pinus thunbergii, Ternstroemia gymnanthera,* and *Pittosporum tobira.* Some *Hemerocallis* species can be seen in bloom as early as May, while others begin to flower in October. The Shore Juniper (*Juniperus conferta*) (Cover) is a striking illustration. It is a beach plant, distributed from the subtropical shores of the Ryukyu Islands to the subarctic coast of Sakhalin. We are beginning to use this species widely as a garden ground cover, and for erosion control on beaches and along highways. Little effort has been made to relate our climatic requiremnts to the source of the material being used. As a start in this direction, I collected cuttings from an unusually prostrate colony that carpeted the beaches along the north Pacific Coast of Honshu. This introduction is being

Fig. 6. The eroded volcanic cones of Osumi, Japan, are dotted with colonies of *Rhododendron sataense, Ilex crenata,* and *Camellia japonica.*

tested by conservationists to see how it does along our Atlantic Coast.

A recent disease problem with forcing azaleas illustrates another objective of screening species and varieties for variation. Cylindrocladium Blight, caused by *Cylindrocladium scoparium,* is reported to have spread at an alarming rate among some varieties of this important florists' crop. Continual selection for forcing attributes from a narrowing base of parental variability, and with little regard for disease resistance, has resulted in extremely susceptible varieties. The disease is rapidly becoming a production factor. This suggests opportunities to evaluate the several species which have been used to develop our present-day races and, hopefully, to locate a usable source of resistance. It will be necessary to assemble valid collections of known origin for each species involved (Fig. 8, 9).

We need in-depth evaluation of this ornamental germ plasm base. A national scheme exists for the evaluation of crop introductions, involving regional introduction stations and cooperation by many pathologists and breeders. Similar facilities are much less in evidence for woody ornamentals. Our national and regional introduction programs are able to conduct only preliminary evaluations on ornamentals. We are not able to provide each of the cooperating institutions and individuals with the quantities of each introduction essential to such trials. Few experiment stations, arboretums, or nurseries have a large enough staff to undertake evaluation of large populations of woody plants. At present, we offer small numbers of plants from the U. S. Plant Introduction Station, Glenn Dale, Maryland, to each of some 200 participants in our evaluation program. Thus we can estimate the behavior of a given introduction only on the basis of reports.

It is not practical to expect any one institution to undertake the screening of large populations of many introductions. A nationally coordinated program needs to be developed. A more conserva-

tive scheme has been attempted regionally with good success among the 13 States of the North Central Region. A series of evaluations over a period of 15 years, made with selected ornamentals, has provided each cooperating State with needed information on plant behavior. Nurserymen and homeowners can then receive sound advice on the range of plants they can grow reliably. Similar cooperative testing programs will benefit other regions of the country and enhance our knowledge of woody ornamental plants in the United States.

The emphasis on beautification, and on wider use of plants in city planning, will require a new look at methods of plant improvement. Plant introductions brought to the United States under the ARS-Longwood exploration program will play an increasing role in these developments.

Fig. 7. A colony of *Ilex crenata* var. *radicans* at Osorizan, Honshu, illustrates the compact spreading habit of this variety.

Fig. 8. Azaleas are among the first invaders of areas disrupted by volcanic eruptions. This is the plant considered by some Japanese as a progenitor of the Kurume azaleas.

Fig. 9. *Cornus kousa,* showing the variability in the size of floral bracts that is encountered in the mountains of central Honshu. Period of bloom is late May to early June according to locality.

The 1969 Philadelphia Spring Flower Show

Angus Paxton Heeps

In keeping with the chosen theme for the 1969 flower show, 'Flowers Around the World', the Morris Arboretum selected the title 'The Orient in Your Garden' for its exhibit. It was designed to demonstrate how rich the gardens of America are in plants of oriental origin, and also inform the public of some of the plant explorers responsible for so many of the beautiful flowers, trees and shrubs we so readily accept today without questioning their native habitats (Fig. 1).

During the last two weeks of December, 1968 a total of 42 trees and shrubs were lifted, balled, and burlapped ready to force for the show opening date of March 9th, 1969. For many of the specimens lifted there was no information in the horticultural literature available to us with regard to forcing technique. Consequently a great deal of information was gained from their various responses: some on time, some early, some late. The winter of 1968-69 proved to be a particularly strange one for forcing. Many plants that are normally entirely predictable, if such a statement can be true of any plant, proved to be troublesome. It was necessary in many instances to keep moving plants from a greenhouse of one temperature to another of cooler or warmer temperature in order to achieve success.

Valuable data on the forcing of *Corylopsis sinensis* were accumulated. We were particularly happy that this species forced reasonably well for

Fig. 1. Philadelphia Flower Show, 1969.

the show and prompted favorable comment from many visitors.

Another yellow-flowering shrub that we had intended to include was *Mahonia bealii*. Unfortunately the two specimens that were lifted for forcing responded each in its own way; one flowering very rapidly, the other too slowly. In each case, however, there was a considerable die-back of leaves.

Ironically, for an arboretum at least, the most highly praised plant proved to be *Primula cortusoides* (See Vol. 19, Number 3 of the Morris Arboretum Bulletin). This primrose, somewhat similar to *P. sieboldii* though more petite by nature, had been grown from seed sown during August, 1968. The eventual potted specimens were placed under fluorescent lighting during January, 1969 in a greenhouse with a night minimum temperature of 70° F. Flower bud initiation was very rapid, so rapid in fact that it was necessary to promote more vegetative growth in order to get a plant of any size worthy for exhibition. The first two lots of flowering stems produced were pinched out and the plants moved to a cool house (55° F. minimum) for two weeks in February. After four heavy feedings, both foliar and root, the plants were again placed under lights for the final three and a half weeks. This time plants were fed every time water was required and were given 16 hours of fluorescent light each day. We were able to have a succession of flowers opening during the whole week of the flower show and were agreeably surprised by the number of questions about this interesting species.

We had expected a number of questions on our eleven-foot lifted specimen of *Metasequoia glyptostroboides;* however, its presence failed to be noticed by most of the people whose attention appeared to be drawn by the more colorful plants on exhibit such as *Rhododendron mucronulatum* 'Cornell Pink', *R. fortunei, R. schlippenbachii,* and particularly by a fine specimen of *Pieris japonica variegata,* the shape of which bore great resemblance to a bonsai specimen.

The literature displayed in cabinets at the front and side of the exhibit proved to be popular also. The color plates in three volumes, Miss Wilmott's *The Genus Rosa, Paxton's Flower Garden* and *Curtis' Botanical Magazine,*

Fig. 2. New walkway from the Rose Garden to the Baxter Memorial under construction.

Vol. 161, gave many people their first glimpse of the art of botanical illustration. We were also able to show by way of books and issues of the *Morris Arboretum Bulletin* Dr. Li's considerable contribution to our knowledge of oriental species.

The great part that Dr. E. H. Wilson played in plant exploration in China did not go unmentioned; his most famous book *China Mother of Gardens* was featured along with *Hortus Veitchii* by James Veitch, member of a family of nurserymen responsible for many plant discoveries; *Flora Japonica* by Carl Thunberg completed the section on plant exploration.

Herbarium specimens appeared to evoke much comment from teenagers who perhaps never realized that such dried herbage really does have great significance to the scientist.

Remarks concerning the exhibit were favorable although there seemed to be no small concern for a fine specimen of *Pinus thunbergi oculisdraconis,* one of the rarer plants in the entire flower show. Because of its interesting variegation in needle color, several individuals who

viewed it from a distance formed the erroneous conclusion that it was unhealthy.

A top dressing of licorice root, generously supplied by a local Philadelphia company, gave a pleasant fresh touch to the finished garden. This licorice root mulch now provides a pleasant footpath in the Arboretum from the side of the Rose Garden to the Baxter Memorial and a still larger walkway from the bottom of the Rose Garden to the top of the Heather Garden (Fig. 2).

For us the Philadelphia Flower Show was a most worthwhile project; every member of the staff participated in its design and layout. Particular credit however, should be given to Mr. Domenick De Marco for his great craftsmanship in design and construction of the display cabinets, Mr. Bruce Keyser for his admirable forcing techniques, Mrs. Betsey Hopkinson for her untiring research of literature regarding the plant hunters of the Orient, and to Mr. Lloyd Nick our artist.

New Associates

The Arboretum is happy to welcome the following new Associates:

Akiba Hebrew Academy
Mr. Edward H. Harris, Jr.
Mr. William R. Krause
Mr. Lamont Moore
Mr. George W. Muller, Jr.
Mr. David B. Ramsay
Mrs. Carol H. Reifsnyder
Mr. Lyman G. Schermerhorn, Jr.
Dr. and Mrs. Donald Scott, Jr.
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Morris

Arboretum Bulletin

LEGES SINE MORIBUS VANAE

JUNE, 1969

Vol. 20, Number 2

Mosquitoes

can pollinate

orchids.

See Page 19

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THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Arboretum.

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Sustaining	$10.00 a year
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Arboretum Activities

It is with great regret that we record the passing of Henry Francis du Pont, a member of the Advisory Board of Managers of the Morris Foundation, on April 10, 1969 at the age of 88 years at his home, "Winterthur" in Delaware. The elegance of the horticultural and art collections at "Winterthur" remain as a monument to his perceptive skills.

Extensive revision and renewal of the living collections are progressing as part of the open-ended project of an active Arboretum. Notable in this enterprise are the improvements in the Rose Garden, Fernery, Swan Pond, Medicinal Plant Garden, and the Baxter Memorial. The planting of a choice selection of Rhododendrons has been completed adjacent to the Baxter Memorial.

(*Continued on Page 32*)

Mosquitoes Can Pollinate Orchids

Leonard B. Thien [1]

Once a plant is identified as an orchid it acquires a special importance. Orchids vary from large bright Cattleya hybrids received by young ladies going to proms, to beautiful Cymbidiums, to dull colored Habenarias unrecognized by most individuals as orchids. Yet all forms, colors, and sizes of orchid flowers are prized by human beings.

It is quite difficult to "define" an orchid as many features characteristic of the family are not possessed by all members. All orchids have some of the following characteristics (Fig. 1; Dressler, 1961):

1. Orchid flowers may be compared with a lily or amaryllis—typical monocots (floral parts in sets of three).
2. The stamens (1-3) are all on one side of the flower.
3. The stamens and pistil are partially or completely grown together (the "column").
4. The pollen is usually bound together in a few large masses ("pollinia").
5. One petal is modified and called a lip.
6. The flower twists around in the course of development.
7. The seeds are tiny and numerous.

Orchids are ubiquitous, occupying many diverse habitats. Some are epiphytes, others terrestrial; some Australian species are completely subterranean.

The floral intricacy of the Orchidaceae is unequaled in the plant kingdom. The complexity of the flowers is ascribed to the evolution of the plants with various pollinators. The column and the lip of the orchid flower are very important in the pollination process (Darwin, 1862, 1877). The stigma, usually a shallow depression on the column, produces a sticky gelatinous material in which the pollinia become lodged. A part of the stigma ("rostellum") is specialized and plays a role in the transfer of pollen to the stigma. In some orchids a portion of the rostellum comes off as a sticky pad with the pollinia, in others it acts as a glue which is rubbed onto an insect visitor which then picks up the pollen.

Some orchids have powdery pollen but most have their pollen grains bound together in packets called pollinia; (each flower may have as many as 12 pollinia depending upon the species). When an insect visits a flower the pollinia become attached to its head or thorax, depending upon floral structure.

The lip, one of the three petals, is usually larger and may have a different color from other members of the perianth. The lip offers a landing place for an insect, positions the insect for the deposition of pollen, and may serve as an attractant by virtue of its shape, color, or odor production. In many orchids a portion of the lip is modified into a spur containing nectar and the lip may then be grooved or have a color pattern that directs the insect to the spur entrance.

Many types of insects and some birds are involved with the pollination of orchids (van der Pijl and Dodson, 1966). That mosquitoes are effective pollinators of plants is generally unknown though it occurs on a scale involving millions of insects and plants throughout northern regions of the world.

Habenaria obtusata, which is mosquito-pollinated, is a terrestrial orchid 2-20 cm tall that has one leaf (Correll, 1950). The flowers, 1-12 per raceme, remain open 10-14 days. They are small, greenish-white except for the white callus (a crest or fleshly outgrowth of the lip), and about 8 mm across (Fig. 2). One of the three sepals forms a hood over the column and entrance to the spur. The narrowly triangular, pendent lip has a small two-lobed callus in the center and a flap of tissue that extends on a diagonal into the spur. The entrance to the spur is blocked by the flap except for two openings (Fig. 3) about 0.3 mm in diameter formed by the lip and the walls of the spur; two side passages formed by the flap and the spur are aligned with the callus. The curved spur is 3-8 mm long and filled with nectar. The two pollinia are about 2 mm long and are contained in anther cells on each side of the entrance to the spur. Each pollinium is divided into granlar packets, interconnected by elastic threads with the basal portion of the pollinium formed into a stalk with a viscid pad (Fig. 4). Each packet is composed of hundreds of pollen grains. The ovary is strongly curved and after pollination and seed development, yields capsules about 7-10 mm in length.

In Wisconsin *H. obtusata* is found in the northern portions of the state in cedar-black spruce swamps. It becomes more cosmopolitan northward in Alaska, Canada, Norway, etc. growing in open heaths or birch forest as well as cold wooded bogs (Case, 1964).

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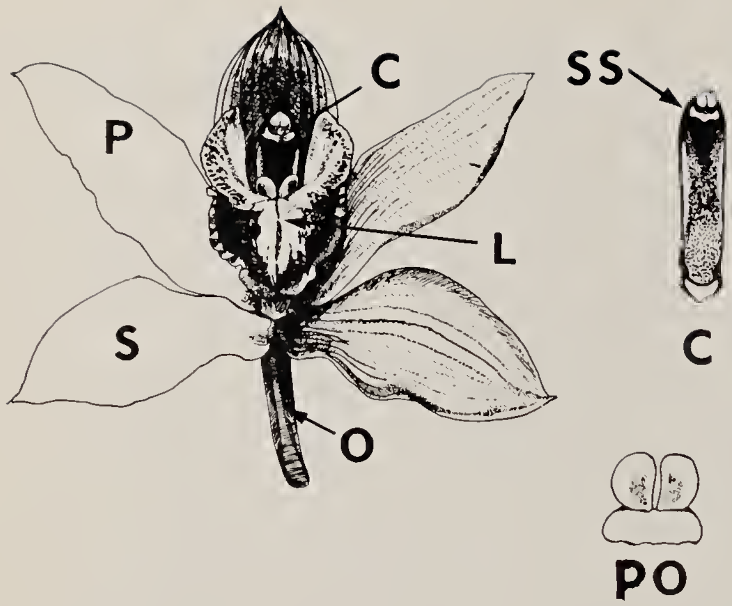

Fig. 1. A Cymbidium flower. C, column; L, lip; O, ovary; P, petal; PO, pollinia; S, sepal; SS, stigmatic surface. Column showing stigma. Pollinia with a portion of the rostellum.

Methods of Study

Today as in the past, persistent observation is one of the principal methods of studying pollinating mechanisms. This process can be quite discouraging and in many cases the pollinating agent is frightened away or simply not caught. In tropical regions of the world where many species of orchids are found, certain plants with a large quantity of nectar (as *Costus* in the Zingiberaceae) are visited by a wide variety of insects, particularly bees. These insects can be captured and the pollen checked to determine the species of plant they have been visiting. Thus one can collect all of a given species of orchid (as evidenced by the pollen from the captured bees) and place them in a small enclosed area to observe the pollination process. Placing suspected pollinators and plants in a cage is not advisable. Many insects will pollinate or be attracted to plants in an enclosed area, but not in nature.

Although an insect may be attracted to a flower by a wide variety of mechanisms, floral odors are prime attractants in many species. C. H. Dodson and H. G. Hill (1966) of the University of Miami have been using gas chromatography to analyze the odors of orchids. This is accomplished by enclosing the inflorescence of a plant in a plastic bag for a short period of time and then withdrawing a minute quantity of air with a micro-pipette. The sample is then analyzed with a gas chromatography apparatus for its various components, and quantified. By mixing various amounts of the identified compounds and placing samples on pieces of paper different types of bees can be attracted. This helps to explain why morphologically closely related orchids do not hybridize, though they grow next to one another in nature!

Observing the pollination of *H. obtusata* in nature is very difficult, as most mosquitoes prefer people to flowers. It is well known that the female mosquitoes draw blood, thereby extracting proteins necessary for egg maturation (Clements, 1963). Since it is difficult to observe the pollination process in nature, the mosquitoes must be captured and those carrying pollinia placed in a cage with dug plants to observe the pollination process. One of the attractants of female mosquitoes to animals is carbon dioxide. Traps using dry ice as a source of carbon dioxide are set in a population of plants that are pollinated by insects. As the dry ice vaporizes the mosquitoes tend to fly upward in a stream of carbon dioxide. The trap is a sort of Indian tepee with the accompanying slot entrance but with a shallow, covered, pan mounted upside down on top (Fig. 5). An opening in the lid of this pan permits entrance of the insects. A small amount of grass or screen is placed inside the pan for the mosquitoes to rest on. The entrance to the container is narrow and operates on the principle of a fish trap, easy to enter but difficult to get out. Once captured the insects can be placed in cages or killed and identified as to species.

Another method of capturing mosquitoes is with the standardized, commercially available

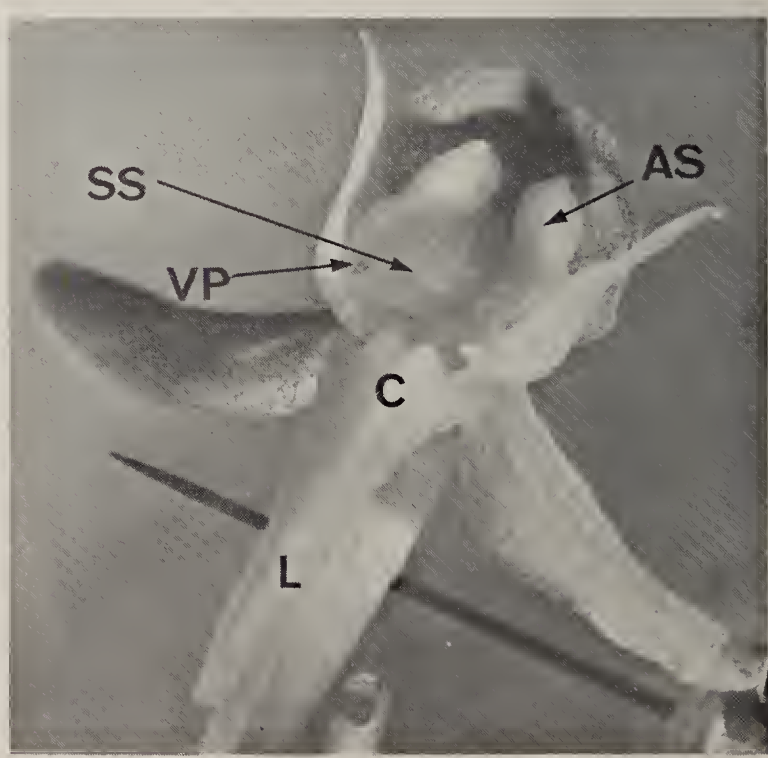

Fig. 2. Flower of *Habenaria obtusata* (X8). AS, anther sac; C, callus; L, lip; SS, stigmatic surface; VP, viscid pad.

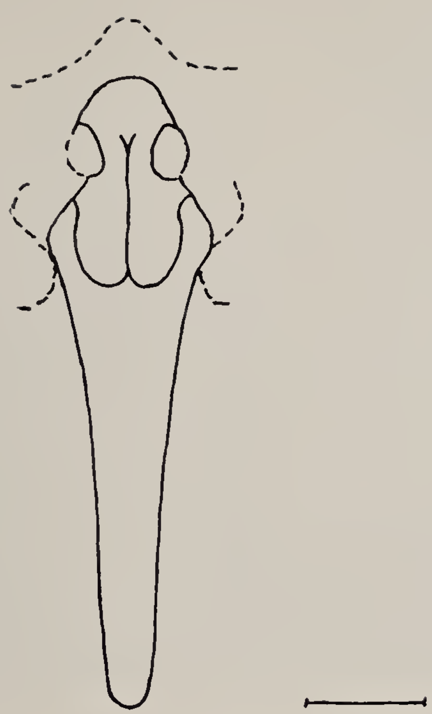

Fig. 3. Drawing of the lip of *Habenaria obtusata* showing the two holes formed by the lip and spur wall. The line indicates 1 mm.

light traps (Fig. 6) used by investigators throughout the world to keep tabs on the number of mosquitoes. A six volt battery is utilized to operate the trap. The insects are attracted by the light and then are sucked into the trap by a small motorized fan. Once in a trap the downdraft of the blades keeps the insects from escaping the container.

Other types of mosquito traps may use color or baits such as small mammals or chickens.

To capture mosquitoes that had visited the flowers of *H. obtusata* carbon dioxide traps were set every 7 days for 24 hours in a population of the plants. The captured insects were either killed and examined for pollinia or placed in glass cages 50 x 30 x 30 cm deep with dug plants in order to observe the pollination process (Thien, 1969).

To determine the density of the plants and the amount of pollination in the natural population under study, 10 plots 5 x 2 m were selected along a 100 m transect at 10 m intervals through its center. Within each plot the number of plants, flowers per plant, and number of pollinia removed were tabulated.

Results

All of the pollinia-carrying insects captured were female mosquitoes of the genus *Aedes (A. communis* and *A. canadensis canadensis).* The pollinia-bearing mosquitoes had the viscid pads of the pollinia cemented to their eyes (Fig. 7, 8). In the plant population studied 15% of the pollinia had been removed from the flowers (533 flowers examined); among the mosquitoes, about 15% of the females of *A. communis* carried pollinia and 9% of the *A. canadensis canadensis.* The highest number of pollinia found on one mosquito was seven.

During the pollination process the mosquitoes hovered briefly about 5 cm from the inflorescence and then alighted on a freshly opened flower and gripped the hooded sepal or a petal with the front pair of legs (Fig. 9). The middle and last pair of legs grasped the petals or adjacent structures. The insect then inserted its proboscis (3 mm long) into one of the two side passages marked by the callus that leads to the spur. Thus aligned upon the flower, the insect took nectar from the spur for about 3-5 minutes. Upon withdrawing its head the pollinium would become cemented to its eye because the viscid base is located just above the passage marked by the callus. Immediately after withdrawing its proboscis from the spur, the insect would attempt to dislodge the pollinium from its eyes. Only the top portion of the pollinium could be reached with the legs, and the force applied was not sufficient to dislodge the viscid pad.

The stigma of the flower is located just above the entrance to the spur and is not well devel-

Fig. 4. A pollinium of *Habenaria obtusata* dissected to show the packets that are interconnected by elastic threads. Each packet contains several hundred pollen grains. The viscid pad has been removed.

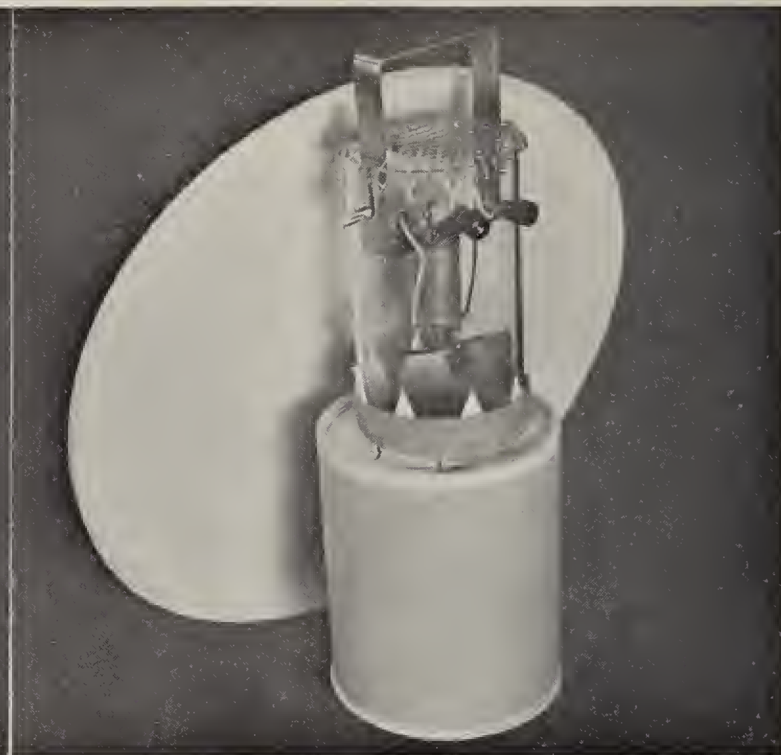

Fig. 5. A carbon dioxide trap constructed of plastic. The trap is approximately 3 feet tall.

Fig. 6. A light trap used to capture mosquitoes. The body is of plastic with a cardboard container attached with rubber bands. The large white disc in the background is mounted on top of the trap to protect the motor from rain, etc. The entire apparatus is usually suspended from a tree branch a few feet above the ground.

oped in freshly opened flowers. A mosquito with pollinia visiting a flower for nectar scrapes the pollinia on the stigma. An entire pollinium is not removed from the insect; only a layer is shed and therefore one pollinium can pollinate many flowers.

Discussion

Not all species of mosquitoes seem capable of acquiring nectar from the flowers of *H. obtusata*. *A. vexans* captured in nature never carried pollinia, and when placed in a cage with the plants were not attracted to the flowers; a few pollinated the flowers but only with great difficulty. At Churchill, Manitoba, females of *A. nigripes*, *A. punctor*, *A. excrucians*, and *A. cinereus* carried pollinia of *H. obtusata* (80% of the captured specimens of some of the species carried pollinia). Individuals of most of the species of mosquitoes named occur around the northern portion of the world in great masses.

Most blood-sucking insects use the nectar from

Figs. 7 and 8. *Aedes sp.* with pollinia attached to eyes (X8).

flowers as an energy source. It has been shown that the peaks of nectar production of flowering plants of the tundra and in the forest are synchronous with the peaks of flight activity of the tundra and forest species of mosquito (Hocking, 1953). A race of *A. communis* has been observed feeding only on nectar and its source of protein for laying eggs in unknown. An analysis of nectar for proteins, particularly of *H. obtusata,* is needed.

The mechanism attracting the mosquitoes to *H. obtusata* is not known. The author, armed with man's comparatively poor sensor, has not been able to detect any odor coming from the flowers. It is known that some species of mosquitoes are attracted by certain flower scents and others repelled. The green color of the flowers may attract the insects, but most species of mosquitoes are attracted to darker colors (red is seen as black). Lactic acid, a byproduct of muscle metabolism, on the skin of humans attracts mosquitoes (Acree, et al. 1968). Further observations and experiments are needed to clarify the attractant mechanism of *H. obtusata.*

Are other species of orchids pollinated by mosquitoes? The genus *Habenaria* is in need of study and is presumably composed of about 500 species distributed throughout the world. In North America alone there are about 50 species. Within the genus there are green-, white-, yellow-, and purple-flowered forms; some purple flowers have fringed lips. Undoubtedly some plants of the yellow and purple-fringed types are pollinated by bees. Many of the green- and white-flowered plants appear to be pollinated by moths, as evidenced by the long spurs (to 3 cm long). But the green flowers of many species are suspect as being pollinated by mosquitoes, and for *H. hyperborea,* green-flowered, there is indeed a report of pollination by mosquitoes.

Most people consider mosquitoes as insects worthy of being wiped off the surface of the earth. Yet it appears that some plants and mosquitoes have co-evolved with the result that the loss of the pest could destroy some beauty man enjoys and endanger important members of northern plant communities.

Fig. 9. *Aedes sp.* resting on a flower after taking nectar. The arrow indicates the attached pollinium.

Literature Cited

Acree, F., R. B. Turner, H. K. Gouck, M. Beroza. 1968. L-Lactic acid: A mosquito attractant isolated from humans. Science. 161: 1346-1347.

Case, T. W. 1964. Orchids of the Western Great Lakes Region. Cranbrook Inst. Sci., Bloomfield Hills, Mich.

Clements, A. N. 1963. The Physiology of Mosquitoes. The Macmillan Co., N. Y.

Correll, D. S. 1950. Native Orchids of North America. Chronica Botanica Co., Waltham, Mass.

Darwin, C. 1862 and 1877. The Fertilization of Orchids by Insects. 1st and 2nd ed. London.

Dodson, C. H. and H. G. Hill. 1966. Gas chromatography of orchid fragrances. Amer. Orch. Soc. Bull. 35: 720-725.

Dressler, R. L. 1961. The structure of the orchid flower. Mo. Bot. Gard. Bull. XLIX: 60-69.

Hocking, B. 1953. The intrinsic range and speed of flight of insects. Trans. Roy. Entomol. Soc. London. 104: 225-327.

Pijl, L. van der, and C. H. Dodson. 1966. Orchid flowers, their pollination and evolution. Univ. Miami Press, Coral Gables, Fla.

Thien, L. B. 1969. Mosquito pollination of *Habenaria obtusata* (Orchidaceae). Amer. Jour. Bot. 56: 232-237.

The Desert Lily

Mildred E. Mathias

The desert is a land of contrasts, a land which has been described as both monotonous and flamboyant, lifeless and friendly, cursed and likeable, of concentrated hideousness and beautiful. It is a barren land which can at times produce wildflower extravaganzas. Nowhere else do we find such contrasts, not only in the reactions of its visitors but in the land itself, a land where water is a luxury yet where the landscape has been sculptured by torrential downpours, a land where the visitor hurries through at night or chooses to linger in serenity to savor its timeless quality, the change in light and shadow from sunrise to sunset, the silhouettes at night, the change from season to season, from place to place, from year to year.

The California deserts are geologically recent, developing in the rain-shadows of the mountains to the west. As the land dried and cooled the tropical forests of broad-leaved evergreen trees were replaced by woodland and scrub vegetation. The desert vegetation of today is a fascinating one to study; it is a vegetation composed of desert tolerators and desert resistors. There are the trees and shrubs which burst into leaf after the rains and flaunt their flowers in the torches of the ocotillo, the delicate brushes of the fairy-dusters, the red clumps of the chuparosa, the golden palo verde and honey-sweet mesquite, violet indigo bush, smoke tree, and ironwood. Growing with these are the stem succulent cacti with exquisite jewel-like flowers in a rainbow of colors.

Alongside the tolerators and resistors are the even more delicately attuned desert evaders: the plants which seem to sense when everything is right, desert annuals which come up after just the right amount of rain at just the right time, one assortment of plants in the early spring after winter rains, a second assortment in late summer or fall after summer rains, plants which rush into flower and seed, sometimes completing their life cycles in as little as four weeks. These are the plants which provide the floral extravaganza, the wild flower fields of lupines, primroses, desert verbena, dandelions and sunflowers. The deep-rooted herbaceous perennials and bulbous plants escape the desert—buried deep in the sand except for a fleeting moment to flower and produce seed above ground when the rainfall is right—desert larkspur and parsley, onions, desert hyacinth, and desert lily.

The desert lily has been called the Madonna of the Desert, a wildflower treasure, delicate, fragrant, often considered rare but in a good year sending up its stalks in every sand patch from Newberry and Bagdad on the Mohave Desert of California to the Imperial Valley, Baja, California and Arizona. Asa Gray, who first described it, aptly gave it the generic name *Hesperocallis,* meaning western beauty, and the species name *undulata* for the wavy-edged blue-green leaves (Fig. 1.). The deep-seated bulb of the desert lily is solid, unlike the true lilies, and is covered with a close-fitting fibrous coat. Indians enjoyed its firm flesh with an agreeable onion flavor as did the early Spanish explorers who called it *ajo,* the Spanish for garlic. From this common name we have the Ajo Mountains and the town of Ajo in Arizona.

The flowers of the desert lily are one and a half to two inches long, white within with a silvery green band on the outside. Each flower stays open for two or three days. Several flowers occur on a stalk which is usually one to three feet tall but six foot stalks have been reported.

The plants are cool season growers, appearing after winter rains and flowering from February to May. In a dry year no leaves are produced and bulbs may not produce leaves or flowers for several years. With one or two inches of rain in late fall or early winter leaf growth starts and one can find the pale blue-green, white-edged, crinkly leaves up to eighteen inches long spreading out on the desert sand. Additional rain controls the development and height of the flower stalk. It has been reported that one to two inches of rain provide sufficient moisture for a foot high stalk with about six flowers while with three to four inches of rain the stalk may be three feet tall with about forty flowers.

This lovely fragrant lily would be a real addition to gardens but so far it has not been cultivated successfully. Rancho Santa Ana Botanic Garden, specializing in California native plants, has tried to grow them with little success. With one seed lot fifty percent germination was reported but the seedlings did not appear the second year. Seed collected in 1935 produced bulbs ready to plant out two years later but these were destroyed by rodents or rotting and never produced flowers. Seed should be collected again, its germination requirements determined, and every attempt made to grow the plants to maturity. How many years it will take is not known. Certainly the bulbs will require sandy soil with good drainage and a long hot dry period. Perhaps pot culture will be the only chance of success. It is a challenge we should meet and thus assist in preserving this lovely flower through cultivation.

Fig. 1 The desert lily, *Hesperocallis undulata*. On Easter Sunday in 1968 a group of conservationists met with representatives of the Bureau of Land Management to dedicate a lily sanctuary north of Desert Center, California. A fence surrounds a large sand flat where lilies have been abundant, thus protecting the area from grazing, vehicles, and people. In a year of good winter rains we should see in this reserve fine examples of that loveliest of desert flowers. A field of desert lilies or even one plant in flower is a never-to-be-forgotten experience. Photo courtesy of Gordon W. Flint, Bureau of Land Management, Riverside, California.

Freezing Injury in Plants

Peter L. Steponkus [1]

Recognition of the existence of an entity is usually more emphatic in its absence rather than in its presence. Awareness of the sun is more pronounced not in the warmth of its presence, but in the chill of its absence and is extreme during a solar eclipse. Similarly, after a late frost in spring or an early frost in fall when flowers and leaves are suddenly raped of their vitality, curiosity in a plant's ability to endure low temperature is aroused.

Superficially, freezing injury is easily diagnosed and its extent is readily ascertained—an early fall frost which renders previously viable plants into limpid mounds of tissue is painfully apparent. The lack of spring bloom reflects the long periods of cold weather the previous winter, the severity of which can be measured in terms of the amount of plant survival. However, to the research worker delineation of what constitutes freezing injury and its precise measurement are more difficult. Knowledge of the mechanism of freezing injury is not only a prime requisite in the elucidation of how plants acclimate to resist freezing temperatures but also to the subsequent application of this knowledge in attempts to expand the geographic distribution of a plant species to more unfavorable environments.

Freezing Injury and Plant Organization

Freezing injury may be studied at various levels of organization within the plant. The relationship of tissue age to freezing injury such as in newly-propagated stock versus well-established plantings may be of interest. The differential lability of various organs as in the case of freezing injury to flower buds or scion wood is of immense importance as is leaf hardiness versus stem hardiness of broadleaf evergreens. Similarly, one may be interested in differences in tissue hardiness, such as the viability of phloem or cambial tissue. Descending through these levels of organization from different organs to tissues of different age, we ultimately arrive at the individual cell as the site of freezing injury, and regardless of the ultimate level of interest we must probe within the cells to understand freezing injury.

Individual cells, rather than being mere sacs of metabolites, are highly refined entities containing various subcellular particles or organelles, each with a specific function. Inspection of a tissue slice under low magnification reveals a group of cells with openings of various sizes between them (Fig. 1). These are referred to as *intercellular spaces,* and their relationship to freezing will be discussed later. Closer examination reveals a cellulose *cell wall* which is lined on the inside by a thin membrane called the *plasmalemma.* While the cell wall imparts mechanical stability to the cell, the plasmalemma is important in retaining the cellular metabolites within the cell yet allowing water and selective metabolite movement between the cells. Inside the plasmalemma is the *protoplasm* of the cell including its many organelles. Among these organelles are the *nucleus,* which plays a large role in directing the activity of the cell, the *chloroplasts,* which contain the machinery for photosynthesis, and the *mitochondria,* which repackage energy in a way the cell requires for its activities. Membranes which enclose these organelles are important to their function and are composed of proteins and fatty compounds (lipids). Proteins are also important to the cell in another aspect in that they are major components of enzymes, the molecules which enable the plant to utilize sunlight, carbon dioxide, and water to form sugars and then to utilize the sugars for energy and growth. Thus the function of proteins is both structural and enzymatic.

The Freezing Process

Two types of freezing are reported to occur in plants and are distinguished by the location of ice formation. *Intracellular* freezing refers to the freezing of water *inside* the cell and is contrasted to *intercellular* freezing which results in ice formation in the intercellular space *outside* of the cell. Intracellular freezing is usually the result of rapid drops in temperature (20°F/minute) which are rarely encountered under natural conditions. In nearly all instances, intracellular freezing is lethal regardless of the hardiness of the plant. More moderate decreases in temperature (3 to 6°F/hour) result in intercellular ice formation which, depending on the hardiness of the plant, may or may not be fatal.

Let us further consider the phenomenon of intercellular ice formation, since this is the type usually encountered in nature. Normally in plants the bulk of the water is contained within the vacuole and cytoplasm. A small portion of the total plant water is found extracellularly in

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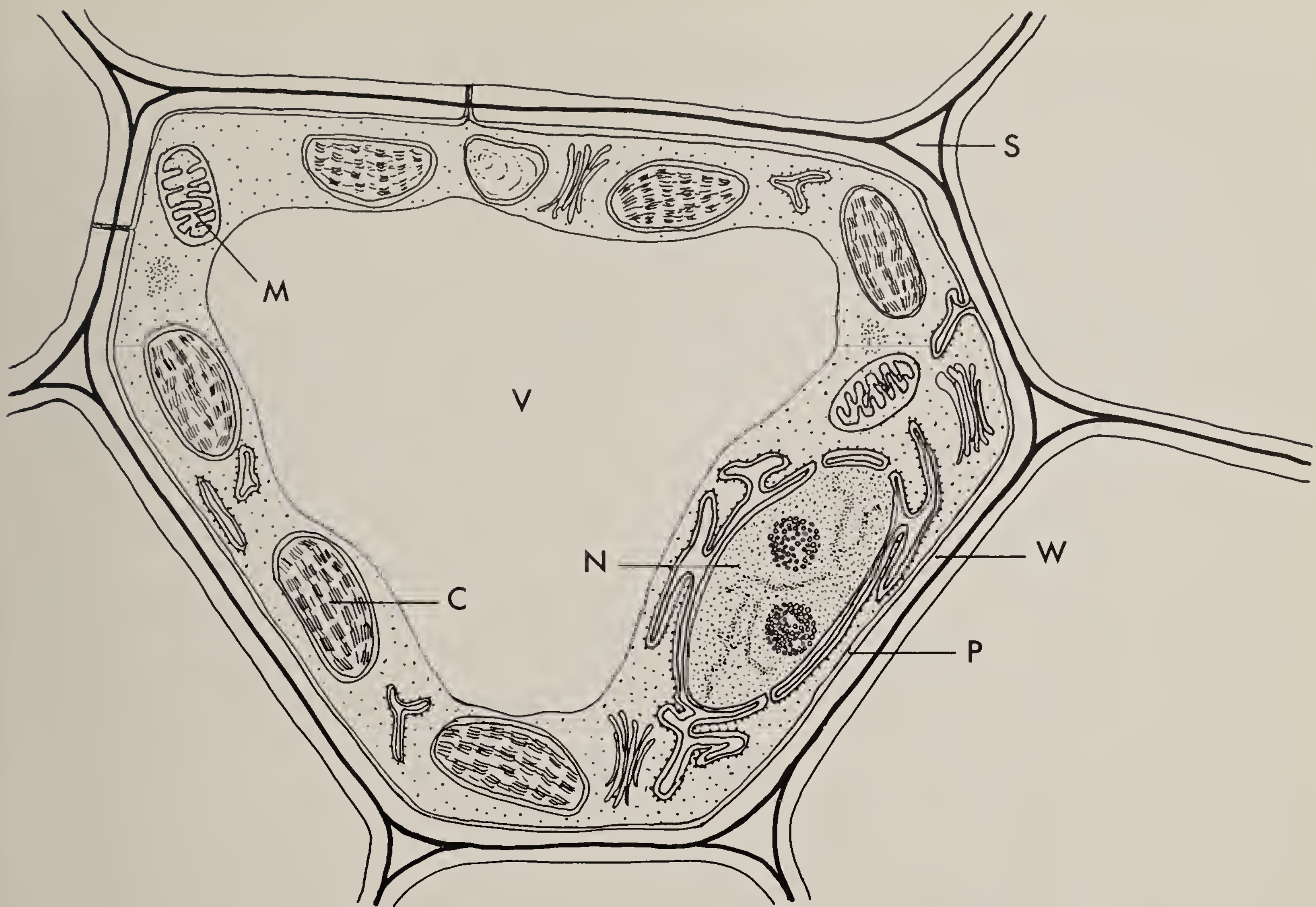

Fig. 1. Diagram of a plant cell, showing some important organelles. M, mitochondrion; S, intercellular space; V, vacuole; C. chloroplast; N, nucleus; P. plasmalemma; W, cell wall.

the intercellular spaces and within the matrix of the cell wall. This water has a minimal amount of dissolved metabolites compared with the cytoplasm and vacuole and hence has a higher freezing point. Therefore, upon exposure to low temperatures, the extracellular water will freeze first and ice crystals will form in the intercellular spaces. As the temperature decreases further, water moves from the cell to the ice nuclei in the intercellular spaces. In so doing, the dissolved materials (solutes) within the cell become increasingly concentrated and increase the resistance of the intracellular water to freezing. The selective permeability of the plasmalemma is very important in allowing the egress of water while retaining the solutes.

Effects of Freezing

In intercellular ice formation we are concerned with the redistribution of water from within the cell to a site external to the cell, and a change in the phase of water, from a liquid to a solid. At first thought, one would expect freezing damage to be due to the enlarging ice crystals or to be merely mechanical in nature. Since water expands when it is frozen, it is logical to assume that freezing injury is due to rupturing of the cells by expanding ice crystals or to the mechanical shearing and tearing by adjacent ice crystals. While this may contribute in part to the overall injury, it is difficult to reconcile this concept with the fact that in *both* hardy and unhardy plants ice crystals are formed. Hence the cells are equally subjected to the mechanical forces, but one tissue survives and the other does not. There are many other aspects which indicate that mechanical damage by ice crystals is not the main cause of freezing injury (Levitt, 1957).

Previously, it was stated that as ice crystals enlarge in the intercellular spaces, water is withdrawn from the cell and the concentration of solutes is increased. In what ways may this removal of water from the cytoplasm and concentration of solutes affect cellular metabolism and integrity? In order to understand this better, we must further examine the architecture of the cell and of membranes in particular. In addition to retaining the cellular metabolites in specific sites, the membranes of such organelles as the mitochrondria and chloroplasts are important in

other ways. They are involved in energy transformations, the transport of materials (usually in the form of electrically charged atoms, ions) and various other metabolic sequences. In fact, from 25 to 40% of the membrane protein of mitochondria is made up of respiratory and energy coupling enzymes. Thus, mitochondrial membranes are not simply metabolically inert 'skins', but complexes of multienzyme systems. These membranes consist mainly of lipids and proteins and are referred to as lipo-protein complexes.

Lovelock (1957) has demonstrated that the stability of lipo-protein complexes is affected by increases in the ionic strength of the medium. Large losses of lipids which affect membrane permeability are induced by such increases. Lipoprotein complexes are also sensitive to changes in acidity. The concentrating of the cyotplasm by water loss can alter the acidity of cells by causing soluble buffering salts such as calcium phosphate to come out of solution.

Cunningham (1964) has found that freezing disrupts the internal matrix of mitochrondia, causes swelling of their internal and external membranes, and ultimately their fragmentation into small, spherical, membrane-bound vesicles. Not only does freezing affect the gross structure of membranes, but also their metabolic capacity. Heber and Santarius (1964) have established that the energy converting systems of mitochrondria and chloroplasts (oxidative and photosynthetic phosphorylation) are irreversibly inactivated by freezing.

The proteins of enzymes are long chains of amino acids, whose shape and configuration are dependent on various bonds and interactions between the amino acids and, to a certain degree, on the water surrounding the protein (Fig. 2). The latter is termed the water of hydration and is important in maintaining the correct configuration required for enzyme activity. Thus, if water is removed from the cell, that portion associated with the protein might be decreased and could lead to a change in shape of the protein, or it could cause the proteins to become less soluble and precipitate. Essentially, this is a dehydration and similar effects can be evoked by high salt concentration. Levitt (1962) has suggested that the removal of water from the protein by freezing causes the formation of new bonds between different proteins or different portions of the same protein. These bonds are from sulfur to sulfur and by the reaction of two sulfurhydrogen (SH) groups which are normally separated by the water of hydration. While this is an elegant model, it is not well supported by the facts. The most notable examples of SH-containing enzymes are a group called dehydrogenases, but it has been shown that, in general, freezing does not eliminate their activity. Furthermore, there are very few SH groups in structural protein.

In summary, freezing at moderate temperatures results in intercellular ice formation which causes a gradual removal of water from the cytoplasm to the intercellular spaces where it is deposited as ice crystals. The dehydration of the protoplasm results in increased salt and metabolite concentrations, changes in acidity and in gas solubilities, and removal of water of hydration of proteins. The cellular proteins, in particular proteins of lipo-protein complexes, and to a lesser extent enzymatic proteins, are then influenced by these changes. The result is loss of membrance integrity and enzyme activity. Thus, in order to resist freezing injury, a hardy plant cell must in some way, either through the evolution of some protectant compounds or the evolution of more stable proteins, protect the proteins from these influences.

Measurement of Freezing Injury

A prerequisite of conducting research in the area of cold acclimation is a reliable method to determine tissue viability following freezing. Many techniques have been used to determine the amount of freezing injury in plants that vary from the measurement of specific metabolic processes to the evaluation of growth after cold treatment. Probably the most conclusive method for determining freezing injury is to expose the previously frozen material to an optimum environment and, after an appropriate period of time, to evaluate the new growth of the plant. Although this method gives an indisputable indication of survival, it requires large numbers of plants and is quite time consuming, sometimes involving several months (Sakai, 1955). Furthermore, it is extremely difficult to ascertain various degrees of injury. Consequently most experimental approaches have been to eliminate the time factor by first finding some easily measured test response that is correlated to survival. Then, after repeated verification of the correlation, results of the test are interpreted as indications of what the survival would have been if the plants were allowed to grow for an extended period. Ideally, the method should eliminate bias associated with visual observations, be based on a quantitative system that could be analyzed statistically, be relatively quick and, above all, supply information for predicting the future performance of the plant.

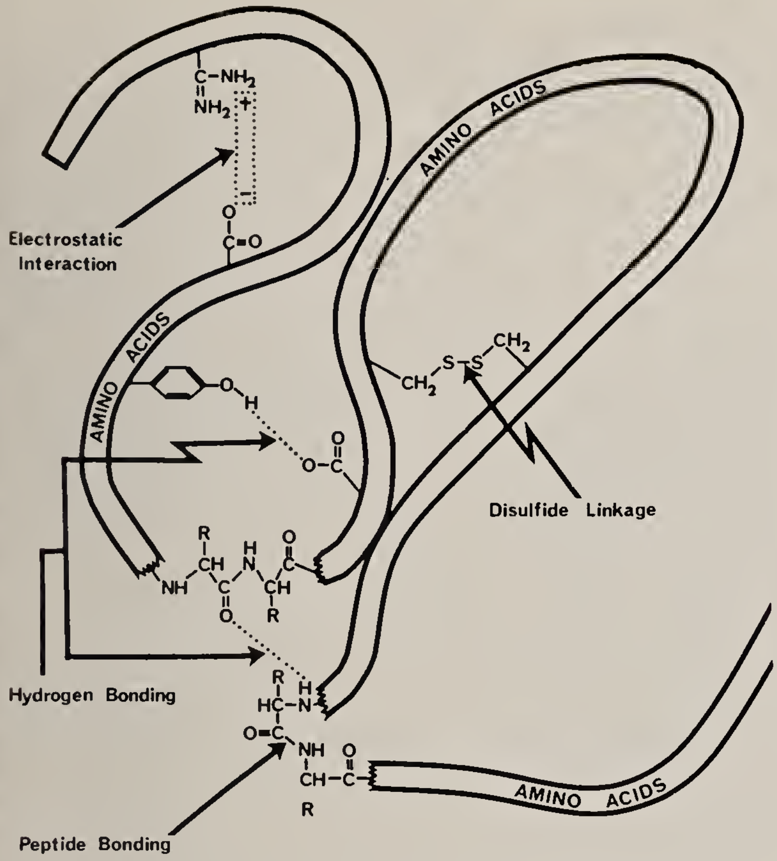

Fig. 2. Types of bonds involved in stabilization of protein structure.

Conductivity Measurements. One of the most commonly used methods simply involves determination of the electrical conductivity of a water solution in which the previously frozen tissue has been immersed (Dexter et al., 1932). The method is based on the fact that following freezing injury the plasmalemma is no longer able to retain electrolytes selectively within the cells, and the greater the extent of injury the greater the movement of electrolytes out of the tissue will be. While this method is usually well correlated with survival (Rollins, et al., 1962), considerable error may be introduced in specific applications (Zippel, 1965; Siminovitch, et al., 1962, 1964).

An extension of this method to overcome one of the disadvantages when the test is used with woody materials has been presented by Siminovitch (1962, 1964). In this modification the amount of amino acids released was measured rather than electrical conductivity. A positive correlation between the amount of amino acids released and the degree of injury was recorded, but was of little value in estimating injury of whole seedlings. A similar problem has been encountered in utilizing the conductivity method for determining viability of flower buds of *Forsythia* (Zippel, 1965). The crux of the problem is that the pistil, the critical portion that determines whether or not the bud will produce a flower, represents only a small portion of the total tissue mass. Thus the conductivity method can at best measure gross disruption of cells, and is only of use on homogeneous masses of tissue. Furthermore, unless specific cellular metabolites such as amino acids are measured, the results may be influenced by materials that are extracted from normally non-living portions of woody tissues.

Plasmolysis-Deplasmolysis Tests. When living tissues are placed in certain strong solutions, sugar for example, the tissue becomes flabby. This is because the water from many cells has moved out of the vacuole, through the cytoplasm, across the cell membrane, and into the surrounding solution. The protoplasm collapses. Such "plasmolysed" cells can readily be distinguished from normal turgid ones under the microscope (Fig. 3). If the flaccid tissue is transferred to fresh water, the component cells will once again become turgid as water moves into them (deplasmolyzed). But the ability of a cell to be plasmolyzed and deplasmolyzed is dependent on the retention of cellular and membrane integrity and has been used as a measure of tissue survival following freezing (Siminovitch and Briggs, 1953; Levitt, 1964). This method is rather difficult to use in tissues other than thin epidermal cells of cabbage or *Tradescantia.* Furthermore, viability of a twig as a whole cannot be judged on the basis of the plasmolysis test in the tissue most easily used in the test because the other tissues of a twig are less resistant to freezing. (Sakai, 1955).

Vital Staining and Fluorescence of Cells: Vital staining is based on the ability of *viable* cells to react in a positive manner with various dyes. Fluorescence of cells in a frozen state has also been shown to differ in plants in various degrees of injury (Krasavtev, 1962). Both of the methods again are limited to small sections of tissue and do not take into consideration performance of the plant as a whole.

Multiple Freezing Points: When tissue is exposed to freezing temperatures and a continuous record of the changing tissue temperature is made, there is a noticeable change in rate of temperature drop due to the release of the heat of water of crystallization when the tissue freezes. Luyet and Gehenio (1937) have shown that living tissues usually exhibit two or more freezing points while dead tissues exhibit only one, and they have suggested that the absence of multiple freezing points in dead tissue might be used as a criterion for determining viability. This technique has been evaluated by McLeester et al. (1969). Moisture content, sample size, measuring instrument placement, and cooling method were

Fig. 3. Diagram of the plant cell of Fig. 1. plasmolyzed.

found to influence the results. Also, in some instances high moisture content prevented resolution of the second freezing point. The influence of these many variables would appear to diminish the desirability of the method.

Reduction of TTC: Another viability test which is based on the metabolic activity of the tissue is the TCC (triphenyl tetrazolium chloride) method of determining cold injury. Essentiallly, TTC is a colorless substance which forms a red derivative (formazan) because of certain metabolic activities within the living cell, most notably reactions catalyzed by a group of enzymes collectively called dehydrogenases (Jensen 1962).

Primarily the TTC test had been used in the past as a qualitative response; if the red derivative was produced, the tissue was considered to be viable (Larcher and Eggarter, 1960; Parker, 1951, 1953; Purcell and Young, 1963). Only limited provisions were made to distinguish between varying degrees of TCC reduction. As a result, observations were reported as dark pink, pale pink, streaked pink, or pink (Purcell and Young, 1963). Another serious disadvantage of the early TTC test (Parker, 1953) was that even if the sample of tissue reduced the TTC to the formazan derivative, the plant might die the next day: it had little predictive value.

A refinement of the TTC test has been made (Steponkus and Lanphear, 1967) for use in woody plants which has eliminated bias associated with visual differentiation between shades of formazan pink and allows one to predict tissue survival at a later date. In addition, the new method provides results in only 15 hours that are indicative of cutting or plant survival after 4 weeks. Only a small quantity of tissue is required (50 to 100 mg) so hardiness determination can be made at precise locations on individual plants. Statistical evaluation of experiments utilizing the technique (comprising approximately 50,000 observations) indicates a high order of reproducibility.

The high correlation between freezing injury and lowered TTC reduction in a system where extra substrates and cofactors are not added, as in the refined TTC test, is probably not due to cold inactivation of dehydrogenases (Steponkus and Gregg, 1968) but to cofactor and substrate limitations. These limitations could be caused by inactivation of enzymes other than dehydrogenases that are required for the continued synthesis of substrates and cofactors. The irreversible inactivation of oxidative phosphorylation by freezing (Heber and Santarius, 1964) represents such a key step leading to a depletion of substrates and cofactors and subsequent decrease in the amount of TTC reduction (Roberts, 1951). Substrate and cofactor limitations may also arise due to diffusion or dilution of the substrates. Since freezing disrupts lipo-protein complexes and affects membrane permeability (Lovelock, 1957), intracellular localization and concentration of substrates at enzyme sites may be greatly diminished.

Thus viability tests which measure the release of electrolytes from injured tissue, or the ability for the cell to deplasmolyze following plasmolysis, or the double freezing point measure only the gross physical intactness of the cells *without determining if they are still functional.* The more subtle damage produced by freezing may be overlooked with such tests. However, in the TTC test, when a tissue is injured the amount of TTC reduced is significantly lessened, and, while being able to measure gross disruptions, the TTC test can also measure these more subtle repercussions of freezing.

In conclusion, we have some insight into the nature of freezing injury although the exact mechanism remains to be elucidated. This information coupled with artificial induction of cold hardiness (see Steponkus, 1968) and tests for determining tissue viability following freezing is the basis for current research in the area of cold acclimation. In a future article biochemical aspects of the cold acclimation process will be considered.

Pertinent Literature

Cunningham, W. P. 1964. Oxidation of externally added NADH by isolated corn root mitochondria. Plant Physiol. 39: 699-703.

Dexter, S. T., Tottingham, W. E. and L. E. Graber. 1932. Investigation of the hardiness of plants by measurement of electrical conductivity. Plant Physiol. 7: 63-78.

Heber, U. W. and K. A. Santarius. 1964. Loss of adenosine triphosphate synthesis caused by freezing and its relationship to frost hardiness problems. Plant Physiol. 39: 712-719.

Jensen, S. A. 1962. Botanical Histochemistry. W. H. Freeman and Co., San Francisco, Calif. 408 pp.

Koenigs, J. W. 1966. Intracellular localization of individual dehydrogenases in frozen plant tissues by means of specific substrates and coenzymes. Stain Technol. 41: 1-7.

————————. 1966. Studies of cytochemical localization of specific dehydrogenases in frozen, diseased tissues of *Pinus*. Am. J. Botany. 53: 1101-1108.

Krasavtev, O. A. 1962. Fluorescence of forest plant cells in the frozen state. Plant Physiol. USSR 9: 359-367.

Larcher, W. and H. Eggarter. 1960. Anwendung des Triphenyltetrazolium chloride zur Beurteilung von Frostschäden in verschiedene Achsengeweben bei Pirus-Arten, und Jahresgang der Resistenz. Protoplasma 51: 595-619.

Levitt, J. 1956. The Hardiness of Plants. Academic Press. New York.

————————. 1962. A sulfhydryl-disulfide hypothesis of frost injury and resistance in plants. J. Theoret. Biol. 3: 355-391.

————————. 1964. Osmotic pressure measuring devices. In: Instrumentation in Experimental Biology. D. W. Newman, ed. MacMillan. New York.

Lovelock, J. E. 1957. The denaturation of lipid-protein complexes as a cause of damage by freezing. Proc. Roy. Soc. 147; 427-433.

Luyet, B. J. and P. M. Gehenio. 1937. The double freezing point of living tissues. Biodynamica 30: 1-23.

McLeester, R. C., C. J. Weiser, and T. C. Hall. 1969. Multiple freezing points as a test of viability of plant stems in the determination of frost hardiness. Plant Physiol. 44: 37-44.

Parker, J. 1951. Moisture retention in leaves of conifers of the Northern Rocky Mountains. Bot. Gaz. 113: 210-216.

Parker, J. 1953. Some applications and limitations of tetrazolium chloride. Science. 118: 77-79.

Purcell, A. E. and R. H. Young. 1963. The use of tetrazolium in assessing freeze damage in citrus trees. Proc. Amer. Soc. Hort. Sci. 83: 352-358.

Roberts, L. W. 1951. Survey of factors responsible for reduction of 2,3,5-triphenyltetrazolium chloride in plant tissues. Science. 113: 692-693.

————————. 1957. Eliminating technically induced variations in the tetrazolium reaction in plant material. Stain Technol. 32: 98-99.

Rollins, H. A. Jr., F. S. Howlett and F. H. Emmert. 1962. Factors affecting apple hardiness and methods of measuring resistance of tissue to low temperature injury. Ohio Ag. Exp. Sta. Res. Bul. 901.

Sakai, A. 1955. A method of testing the survival of the twig. Low Temp. Sci., Ser. B. 13: 43-50.

Siminovitch, D. and D. R. Briggs. 1953. The validity of plasmolysis and desiccation tests for determining the frost hardiness of bark tissue. Plant Physiol. 28: 15-24.

Siminovitch, D., H. Therrien, J. Wilner and F. Gfeller. 1962. The release of amino acids and other ninhydrin-reacting substances from plant cells after injury by freezing; a sensitive criterion for the estimation of frost injury in plant tissues. Canadian Jour. of Botany. 40: 1267-1269.

Siminovitch, D., H. Therrien, F. Gfeller and B. Rheaume. 1964. The quantitative estimation of frost injury and resistance in black locust, alfalfa and wheat tissues by determination of amino acids and other ninhydrin-reacting substances released after thawing. Canadian Journal of Botany. 42: 637-649.

Steponkus, P. L. 1968. Factors affecting cold acclimation of *Hedera helix*. Morris Arboretum Bulletin 19(3): 41-46.

Steponkus, P. L. and F. O. Lanphear. 1967. Refinement of the triphenyl tetrazolium chloride method of determining cold injury. Plant Physiol. 42: 1423-1426.

Steponkus, P. L. and J. M. Gregg. 1968. Effect of freezing on dehydrogenase activity and reduction of triphenyl tetrazolium chloride. Plant Physiol. 43: S-5.

Zippel, C. B. 1965. A study of the conductivity method for evaluating low temperature injury of *Forsythia* flower buds. MSc. Thesis, Cornell University, Ithaca, New York.

Arboretum Activities

(*Continued from Page 18*)

Through research activities of the staff, including specialized collection and exchange activities with other institutions, some 2000 specimens have been added to the Herbarium. This facility is uniquely valuable in many aspects of botanical and horticultural teaching and research.

Some sixteen different taxa of woody plants were assembled for the Annual Plant Distribution days on May 23 and 24. Included in the distribution was the unusual "zebrina" form of the Himalayan Pine (*Pinus griffithii* McClelland). The specimen of this variegated pine in the Morris Arboretum is considered to be the largest mature specimen in the United States.

The Staff

During the spring semester, 1969, *Dr. Li* has been continuing his research on the "Flora of Taiwan" at the Smithsonian Institution under the auspices of a National Research Council Fellowship.

During the spring semester *Dr. Allison* has been teaching a lecture and laboratory course, The Biology of the Fungi, in the Department of Biology.

Mr. Keyser attended the 1969 National Conference of the American Rhododendron Society at Callaway Gardens, Pine Mountain, Georgia, April 20-23, 1969.

On April 24, *Dr. Dahl* presented an illustrated lecture on "The Arboretum" before the Philadelphia Botanical Club at the Academy of Natural Sciences. Included was a presentation of the excellent, new color film produced by the U. S. National Arboretum. Dr. Dahl gave a similar presentation before the Pennsylvania-Delaware Chapter of the International Shade Tree Conference, Inc. on May 2, 1969.

On September 16, 1969, the Morris Arboretum will be one of the host institutions welcoming and supporting the 24th American Horticultural Congress which this year is being held in Philadelphia. We look forward with pleasure to a series of interesting and stimulating meetings.

A. Orville Dahl

About Our Authors

Dr. Mildred Mathias is Professor in the Department of Botanical Sciences, The University of California, Los Angeles, where she is also Director of the Botanical Gardens and Herbarium. She has been a distinguished member of many professional organizations, and served as President of the Society of Plant Taxonomists in 1964.

Professor Mathias has not confined her activities to taxonomy alone. Because of her interest in horticulture and her efforts as writer, editor, and consultant, a great many people have enjoyed enriched views of the plant world.

Dr. Leonard B. Thien is Assistant Professor in the Department of Botany at the University of Wisconsin. The article describing his interesting studies of mosquito pollination of orchids is his first contribution to the *Bulletin*.

Dr. Peter Steponkus, who obtained his Ph.D. degree in plant physiology at Purdue University, is Assistant Professor of Ornamental Horticulture at Cornell University. The first in his series of three articles on plants and cold appeared in the September, 1968 issue of the *Bulletin*. In it he explained how cold acclimation is the attaining of the cold-hardy condition in those plants whose heredity enables them to respond favorably to certain environmental cues. He discussed the way the effects of exposures to low temperature and to light on cold acclimation could be studied and why English Ivy is a valuable plant for use in such exploration.

Morris Arboretum Bulletin

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The spice section of the New Market in Addis Ababa, said to be the largest native market in Africa. In Ethiopia these open-air markets are excellent sources of samples of important spices and medicinal plants.

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THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Arboretum.

CLASSES OF MEMBERSHIP

Sustaining ....$10.00 a year	Sponsoring ....$100.00 a year
Supporting ....$25.00 a year	Donor $500.00

Arboretum Activities

Thirteen students in the Department of Landscape Architecture and Regional Planning, University of Pennsylvania, received instruction in taxonomy and ecology from *Dr. Michael H. Levin* during the second summer session.

Our Morris Arboretum Graduate Student Fellows, *Mr. K. Y. Lee* and *Mr. J. Y. Hsiao* are currently continuing the project of cataloguing all species growing in the Arboretum. In addition, seed collections are being made in order to facilitate reactivation of our seed exchange activities.

The summer brought a new project to the Arboretum. Under the sponsorship and direction of the Pennsylvania Horticultural Society, with members of the Morris Arboretum staff cooperating, a summer school for children between the ages of 11 and 16 years of age was held in the Bloomfield section of the Arboretum. Twenty-four children attended sessions four mornings a week from June 23 to August 29. During this time each student had the opportunity to learn elementary horticultural theory

(Continued on page 59)

THE SEARCH FOR PLANT SOURCES OF ANTICANCER DRUGS

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AND

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Fig. 1. On the way out of the jungles of southwestern Ethiopia with a full load of plant material. The Bonga road is reputedly the worst in Africa.

INTRODUCTION

Plants contain such a vast array of diverse chemical substances that any search of this resource for unusual chemical structures or unique physiological activity can anticipate some degree of success. The search for useful anticancer drugs logically turned to this resource and, over a period of 12 years, has been rewarded with considerable success. Crude extracts prepared from about 1,200 plant species are capable of damaging cancer growth in laboratory animals. The anticancer activity of many of these plants is now known to be due to substances that have no drug potential. But a small though significant number are showing promise as potentially useful drugs of the future.

It would be rash to anticipate that drugs of plant origin will ultimately cure the multiplicity of diseases known as cancer. But we are confident that these products will eventually contribute significantly to the well-being of the afflicted. Indeed, one such drug, vincristine, obtained from the periwinkle (*Vinca rosea* L.), is currently one of the most important drugs used in the treatment of acute childhood leukemia. It is also used in the therapy of some other kinds of malignant disease.

The earliest known record of the use of plants for treating cancer or cancer-like disease is the Ebers papyrus which dates from about 1550 B.C. This early Egyptian work recommended more than 40 plants for treatment of tumors and warts and other possibly malignant growths. Among the plant products recommended were barley, garlic, flax, absinth, coriander, figs, onions, papyrus, dates, and grapes. For most of these, imagination must have played a greater role than efficacy. But it may be more than coincidence that this early work also recommended the berries of juniper, a plant now known to produce a substance that is selectively toxic to cancer cells. The Ebers papyrus also recommended yeast, the source of folic acid which led to

Fig. 2. Collecting bulbs and leaves of *Hymenocallis latifolia* Roem. in the Florida Keys.

use of folic-acid antagonists in cancer therapy. During the subsequent 3,500 years, the use of plants for treating cancer, both in folklore and in medicine, has increased until there are more than 3,000 species now recorded for this use.

The modern search for anticancer drugs began immediately before World War II. War-time success in developing antimalarials and antibiotics encouraged interest in cancer chemotherapy programs by pharmaceutical companies and private research organizations. The major stimulus came in the form of encouragement from the United States Congress, also impressed by war-time achievement in the drug field, which led to the establishment of the Cancer Chemotherapy National Service Center (CCNSC) of the National Cancer Institute in 1955. The present intensive search for anticancer drugs began in 1956 and focused first on synthetic chemicals and fermentation products. From January 1956 through June 1960, more than 110,000 such materials were screened for anticancer activity.

Plant products first entered the program during the Fiscal Year beginning July 1957, and an average of about 5,000 have been tested during each year since 1961.

Screening For Anticancer Activity Objectives And Philosophy

The objectives of this program are to bring the broad spectrum of chemical substances present in plants before a screen of selected cancer systems in living animals; and, to methodically sift out and identify those of potential value for chemotherapy of cancer in man. Screening can be considered to cover the entire process from collection of plants in the field to the final evaluation of clinical trials of a new drug.

Two logical avenues can be followed in screening plants for any biological activity. One can look first, employing chemical techniques, for classes of phytochemicals such as alkaloids and glycosides that are most likely to produce pharmacological activity. Such substances, once locat-

ed and identified, can then be screened in animal systems for desired activity. This avenue is likely to yield a fairly high number of positive leads, but will not discover physiologically active substances with totally new and unique structures. Or one can, employing laboratory animals, search for plants capable of producing a desired effect, then isolate, identify, and further evaluate responsible chemical compounds. The yield of positive leads is likely to be lower, but the chances of detecting a broader array of pharmacologically active chemical structures are much greater. While the former approach might be appropriate to a short-term program, the latter is better suited to a long-term program, and such broad screening, completely at random, has been followed in the current long-term search for plant sources of anticancer drugs.

Procurement For Primary Screening

Procurement of plant materials for primary screening is conducted primarily by botanists of the Agricultural Research Service, U. S. Department of Agriculture, who since 1960 have supplied almost 19,000 plant samples. Many other individuals or institutions have supplied smaller numbers of plant samples or extracts ready for screening.

Within the USDA, the procurement effort is centered in the Plant Resources Investigations of the New Crops Research Branch (NCRB), formerly Plant Introduction Section. This organization has a tradition of more than 60 years of procurement of plant material for all phases of agricultural, biological, and chemical research.

This long and profitable experience in plant exploration and introduction, resulting in the worldwide procurement of some 500,000 plant collections, has established NCRB as the largest plant procurement agency in the United States. NCRB continues to conduct a traditional plant introduction program. It serves as a worldwide clearing house for plant materials needed not

Fig. 3. Collecting stems of *Dracaena steudneri* in the Bada Buna Forest, near Jimma, Ethiopia.

only by American agriculture, but by agriculturists of many other nations.

The long-term tradition of cooperation with botanical and agricultural institutions in other countries contributes immeasurably to our present program. Contacts abroad permit economical procurement of items of special interest when needs from a foreign area are not sufficient to justify cost of full-scale field projects. These contacts prove helpful to botanical explorers in planning explorations, in making limited field time abroad more effective, and assuring safe and speedy dispatch of collections.

Procurement of plant samples for anticancer screening by USDA botanists was first conducted largely in the continental United States. Field projects were also conducted in Mexico during the early years and some procurement, supported by Public Law 480 funds,[3] was accomplished overseas, especially in Pakistan, Korea, Spain, Yugoslavia, Turkey, Uruguay, and Israel. More recently, procurement by USDA botanists has been increasingly directed to overseas areas including Puerto Rico, Ethiopia, Kenya, Tanzania, and Uganda. Currently, intensive field work is centered in East Africa, with plans to move next to South Africa.

Fig. 4. Ethiopian laborer splitting woody stems of a tree lily, *Dracaena*, to hasten drying.

In addition to collections made directly by USDA botanists, every effort has been made to obtain samples through commercial sources, including suppliers of drug plants, seed, and bulbs. Seed of several hundred plant species are available from domestic and foreign outlets at reasonable cost. Collection of seed by USDA botanists would have been prohibitively expensive; hence, these arrangements with commercial suppliers have permitted the testing of many such materials that would otherwise not be screened. Bulbs of many ornamentals are also available. They have been especially welcome because most are members of families that are well-known sources of pharmacological activity.

It has become evident that field work in the United States is considerably less economical than that conducted overseas. Day-to-day operating costs for a single collector are somewhat less in the United States; but, the daily return of plant material is far greater in many overseas locations, especially in developing countries where vegetation is rich, and where unsophisticated, but effective, labor is abundant and inexpensive. For example, the cost of hiring and supporting one field assistant in the United States will purchase the service of 90 day-laborers in Ethiopia, about 35 in Kenya, or 18 in Mexico. Cost of labor is always a significant part of field expenses, especially when one is collecting large lots of plant materials for isolation of active constituents. The reduced cost of labor more than offsets the somewhat larger overall operating costs in foreign areas, including the extra expense of transporting a botanist overseas. The normally high cost of shipping collections from overseas points to the United States has been offset by negotiation of a special freight-rate classification. This has reduced this cost to an amount comparable to the cost of shipping domestic collections.

Collection of plant samples in the field can be an uncomplicated methodical day-to-day operation; but, in the face of increasing costs and a level budget, innovations must constantly be brought into the field procedure to increase daily production. Over a period of ten years, field techniques have been developed that have raised production from 10-15 collections per day to about 60 samples per day with a return

3 Under P.L. 480, American agricultural surpluses were sold abroad for foreign currencies, and these currencies were available for supporting research of mutual value to the United States and to the country in question.

Fig. 5. Drying samples of wood and roots at the Kakamega Forest Station, western Kenya.

of as many as 100 samples under exceptionally favorable conditions.

Field experience over this ten-year period has evolved a system that is now in full application in East Africa, the primary center of current field work for this program. The following commentary on procurement is, to a great extent, descriptive of the field work in that region, but it is applicable to other similar areas.

Prior to the initiation of a field project, a long-term plan is laid out so that the collecting will yield the best sampling of the plants of the region (i.e., a maximum number of genera and species with a minimum duplication of species). A first priority area is selected because of its richness and accessibility. Secondary, less accessible areas are selected to complement the first. Selection of the latter may be based on climatic or phytogeographic differences. For example, after intensive collecting in the rich forests and grasslands in the vicinity of Nairobi, Kenya, at an elevation of 5,500 ft. and an annual average rainfall of 34 in., the field effort might move to the upper slopes of Mt. Kenya where, at an elevation of 8-10,000 ft. and annual average rainfall of 70 to 80 in., the species content of the rich forests is quite different. Or the project might move to the Kericho area, where the combination of medium altitude (6,500 ft.) and long rainy season with average annual rainfall of 72 in., produces extremely lush vegetation with many species not seen elsewhere. Other secondary sites might be Kakamega forest in western Kenya, which is the most easterly outlier of the Congo rainforest, or the Usambara Mountains of northeastern Tanzania, which, because of geographic isolation and geologic history, has a flora with a high degree of endemism.

Other factors also enter into selection of field sites. Accessibility by motor vehicle is important because a large volume of plant material is involved. The use of pack animals or porters is not out of the question, but is impractical under most circumstances. A factor that is especially critical is the capability of drying samples in the field. In general, richness and diversity of vegetation are proportional to total annual rainfall. Drying plant samples in a humid environment can be frustrating unless artificial heat is used. The latter is impractical unless volume of collection is greatly reduced or mobility is severely sacrificed.

A principal reason for selection of East Africa for field work was a climate characterized by marked rainy and dry seasons, the former ideal for development of lush vegetation, the latter ideal for conducting field work and drying col-

lections. In some areas the term "dry season" refers to the months when rainfall is at a minimum. Even during the dry period daily showers may occur which, in combination with constant high humidity, make drying difficult. Such areas are often ideal, however, because of rich vegetation. The rich vegetation of these humid areas can often be exploited in regions of uneven topography by locating areas nearby that are in rain shadows and have minimal rainfall and low humidity.

In East Africa the American botanist is accompanied by an African botanist who is a member of the staff of the East African Herbarium (Nairobi) and two African field assistants who, after thorough training, are completely familiar with the required field procedures. In each area where collecting is conducted, a team of local workers is recruited and trained. The collecting proper requires little sophistication, but helpers must learn to follow simple procedures required to assure proper sampling, proper processing of samples, and reliable documentation of the plant materials collected.

These unsophisticated workers have no concept of the importance of correct labeling of collections. They cannot be depended upon to follow logical procedures expected of an educated worker. Methods must be developed that make errors nearly impossible.

Each species encountered is sampled as thoroughly as possible, because some plants concentrate their chemical products in individual organs; for example, in roots, bark, or fruit. Small herbs usually yield a single sample representing the entire plant. Large herbs often yield a separate sample of roots. Trees usually yield separate samples of roots, bark, wood, twigs and leaves, and often a sample of flowers or fruit. All samples are prepared in an amount that, when thoroughly dry, will weigh at least one pound.

Most non-woody plant samples are processed through a portable gasoline-powered compost mill to chop them into small pieces that will dry quickly. Use of the mill was originally intended for chopping samples after drying to reduce their bulk and consequently reduce the high cost, based on volume, of shipping samples to the United States. When field workers noted that almost all types of non-woody plant material pass through the mill without leaving residue to contaminate samples that follow, the mill was used to process fresh samples to hasten drying.

Samples are dried in the sun if the weather is favorable, but covered space is employed for drying during rainy periods. In an environment like that of East Africa with marked wet and dry seasons, field work is scheduled during the dry season, preferably the early months, when vegetation is most luxuriant and drying conditions are at their best.

All collections are carefully documented to identify every sample submitted for screening and to precisely record the location where each was collected. Accurate documentation is essential to permit the return of future collectors to the same location for procurement of duplicate samples of those which demonstrate significant anticancer activity. Each species sampled is assigned a number which is placed (1) on all samples of that species, (2) on notes made at the time of collection which specify and describe the collection locality (including precise map coordinates), and provide a description of the plant, the date collected, and information on local usage, and (3) on dried herbarium specimens collected at the same time. These "voucher" herbarium specimens provide a basis for scientific identification of the plants and a permanent record of each. Five vouchers are collected for each species sampled for deposit in herbaria in Africa, Europe, and the United States.

The dried plant samples are assembled, crated, and shipped by ocean freight to the United States.

All imported plant material passes through USDA's Plant Inspection Station in Washington, D. C. Plant Quarantine Inspectors examine incoming shipments to detect dangerous plant diseases or animal or insect pests. Collections harboring serious pests that could become a threat to American agriculture are fumigated to destroy infestation. After these precautions, the samples are forwarded to a laboratory for preparation of extracts.

Preparation of Plant Extracts

Most extracts for preliminary screening are prepared under CCNSC contract by WARF Institute, Inc., in Madison, Wisconsin. Just before samples are ground in a hammer mill, a few of the larger fragments are removed, placed in a small plastic bag, and labeled with the sample number. If the extract prepared from the sample is active in tests to follow, these fragments will be recovered and compared with the voucher specimen documenting the sample to further

Fig. 6. Processing a large samlpe of *Dracaena steudneri* stems. The side seam of the bag was removed so that the plant material would fall on a tarpaulin.

verify its identity, and compensate for any errors that might have been made in the field or while the samples were being processed for shipping.

After grinding, 100 to 150 grams of the pulverized dry plant material are extracted at room temperature by mechanical mixing in open beakers with 50% aqueous ethanol. After mixing for an hour, the mixture is filtered. Then the alcohol and water are removed from the extract, first by evaporation at mild temperature, then by freeze drying. The dry extracts are bottled and labeled, and forwarded to another laboratory for screening.

The extraction process is designed to remove a broad spectrum of chemical substances from the sample at mild or very low temperature, neither of which is likely to cause breakdown of potentially useful substances. Most of the final extracts are powdery, but some are sticky, gummy, or resinous.

Bio-assay In Laboratory Animals And In Cell Culture

Screening of plant extracts is conducted by nine laboratories working under contracts with the CCNSC. These laboratories currently conduct about 45,000 tests each year with plant products, fermentation products, animal products, and synthetic chemical compounds. About 12,000 tests are devoted to higher plant products. Of these, one-third involve preliminary screening, two-thirds involve testing of fractions and crystalline products.

Plant extracts have been tested against a variety of experimental cancer systems in laboratory animals and in culture. For the screening program to be meaningful, that is, ultimately productive of clinically useful drugs, it must be predictive for anticancer activity in man.

Screening originally employed three cancer systems in mice that were selected after consideration of their response to drugs then in clinical use. Other systems were later introduced, with rats and hamsters as additional hosts, to increase the diversity of the screen in hope of finding additional systems with good predictability for clinical activity.

About three years ago, this broad spectrum of experimental systems was subjected to an intensive evaluation with drugs known to show useful clinical activity in man. This evaluation indicated that a screen of just two systems would predict the activity of almost all drugs of clinical value.

The screen was modified to include lymphoid leukemia L-1210 (LE) in mice and Walker-256 intramuscular rat carcinosarcoma (WM). LE is still regarded as the most useful screening system for predicting clinical activity. It is predictable for cancer in general, not specifically for leukemia. LE is rather insensitive to natural products and very few plant extracts show activity against this system.

Many plant extracts have shown activity against WM. Its use has been discontinued in the primary screen until active constituents can be identified and clinically evaluated to determine whether further use of this system is likely to be profitable. Although it was dropped from the primary screen, WM is still used for fractionation studies to isolate and identify WM-active plant constituents.

Some plants produce potentially useful substances in such minute amounts that they cannot be detected by screening extracts in laboratory animals. The activity of such extracts can sometimes be detected by KB cell culture. When KB activity is concentrated by preliminary chemical fractionation, a substantial proportion of the concentrates show activity in animal test systems. KB cell culture has been used routinely since 1960 and has selected many plant extracts which were inactive in animal test systems. A good example is the activity of *Taxus brevifolia* Nutt.; detected first by KB, it proved active, after concentration, against LE.

Fig. 7. Grinding leaves of a succulent with moka-cha (mortar) and zena-zena (pestle) to hasten drying. These Ethiopian implements are normally used for grinding grain, oilseeds, and spices.

Recently, P-388 leukemia (PS) was added to the screen. It is very similar to LE, but is much more sensitive to known anticancer agents than the latter, and is now being studied as a possible substitute for LE in screening natural products.

Rapidly growing cancers are more sensitive to drugs than are slow-growing cancers. This is probably because a much larger proportion of cells making up the former are in a state of division at any one point in time. These dividing cells are believed to be much more sensitive to drugs than are those that are not dividing. All cancer systems so far used in screening are rapidly growing types. Attention is now being given to selection of an appropriate slow-growing mouse or rat cancer for addition to the screen.

The Walker-256 is a solid cancer implanted in the right hind leg of an albino rat. Lymphoid leukemia L-1210 and P-388 leukemia are cancers of the circulatory system, implanted in the peritoneum of selected strains of hybrid mice bred especially for this program.

In preparation for screening of plant extracts, living cancer cells of the appropriate system are removed from a newly sacrificed animal and implanted in a large number of rats or mice. Some of the animals will serve as controls; that is, their cancer will be allowed to grow without treatment. The other animals are sorted at random into groups of six. The animals in each of these groups will be treated periodically with a crude experimental drug in the form of a plant extract dissolved or suspended in saline solution. Anticancer activity is determined by comparing cancer growth in the treated animals with that in the untreated control animals.

Seven days after implantation, Walker-256 cells in the control animals will have grown to form a solid tumor nearly an inch in diameter. The tumor will weigh between 5 and 7 grams, about 10% of the normal weight of a tumor-free

test animal. A plant extract is considered to demonstrate significant activity if it reduces the mean tumor weight of the six treated animals to less than 42% of the mean tumor weight of the control group.

A leukemia is not a solid tumor and its growth cannot be measured by weight. Activity of plant extracts against LE and PS is determined by comparison of survival time of treated and control animals. Mean survival of untreated control animals varies from 8 to 11 days. Significant activity against LE is reflected by a 25% increase in mean survival time in comparison with the untreated animals of the control group.

KB cell culture was derived from a human cancer of the nasopharynx and is cultured in artificial media in test tubes. Activity against KB is based on the capability of a dilute plant extract (20 micrograms per milliliter or less) to reduce cell growth by 50%. This system is employed as a "pre-screen," that is, to select plant extracts worthy of further testing in animal systems.

Screening experiments are not designed to detect highly spectacular anticancer activity, but to detect activity of a lower order that is significant and reproducible. Evaluation of extracts proceeds and a sequence of up to four independent tests. An extract, active in the initial stage, is tested with a second group of animals. If the original activity is reproduced, a new extract from the same plant sample is prepared and subjected to a third test. Activity at this stage is the basis for preparation of still another extract from the original sample for a fourth and final test. In the first two tests, the extracts are administered to a single group of animals. In the third and fourth tests, the extracts are administered, in a dose-response experiment, to four groups of animals at four dose levels. These doses are double, equal to, one-half of, and one-fourth of the dose level that was acceptable in the second test. Plants that pass the final test are considered "confirmed actives." These become candidates for intensive chemical research to isolate and identify the chemical substance responsible for their anticancer activity.

The testing of a single plant sample may be completed in as little as six months, but may require a year or even two years. Many plants contain highly toxic substances and their extracts kill all of the animals to which they are initially administered. All toxic tests are repeated at a

Fig. 8. In warm, sunny areas plant samples can be dried readily in burlap bags. Here, samples are being tied to a rack on top of the field truck to take full advantage of air flow while the vehicle is enroute to the next collecting site. Garfield County, Utah.

lower dose (half or one-fourth the toxic dose) and testing is continued until a non-toxic, active, or inactive test is achieved. Testing begins at a dose of 500 milligrams of extract per kilogram of animal body weight. When highly toxic substances are present, the final non-toxic dose may be less than one-hundredth of the dose initially administered.

The screening program is generating a massive volume of information on the toxicity of plants. Even though the test animals are tumor-bearing, toxicity to these animals correlates well with toxicity to man and livestock. Of thirty species of plants selected at random from a recent review of the poisonous plants of the United States and Canada that were screened for anticancer activity, 13 were highly toxic and 15 were moderately toxic to tumor-bearing mice. An example is the well-known poisonous seed of jequirity bean (*Abrus precatorius* L.). Aqueous extracts of these seed were retested eight times, each at a lower dose, until a non-toxic dose of .006 mg. per kg. of animal weight was reached.

The initial screening of plant samples eliminates about 95% from further consideration. About 5% show enough anticancer activity to justify fractionation, isolation, and identification of active components.

Procurement of Confirmed Active Plant Materials

When the screening of a collection of plants from a single geographic area is complete, a new field project is scheduled for "recollection" of confirmed-active plants from that area. A botanist returns to the original site of collection, at the same season of the year, and obtains a large quantity of the plant that as nearly as possible duplicates the original collection.

Fig. 9. Drying and bagging samples in the attic of an old tea factory near Kericho, Kenya.

We know that plants vary in their chemistry as well as in their morphology. A plant species that produces an active constituent when collected on one soil type in April may not produce that same constituent when growing an another soil type. Or it may produce the same substance but in too small a quantity to be detected by bio-assay. If the recollection is made in September the plant, by then, may have modified the active constituent to a different inactive compound. Genetics, environment, season of collection, and other factors can influence plant chemistry. Consequently, an effort is made to duplicate the original collection as closely as possible. In addition, in order to increase the chance that a new active collection can be made available to the chemist, one or more additional recollections are made at different locations or at different times of the year. In practice, these multiple collections, in lots of 50 lbs. or more, can be made only in areas where abundant labor can be used.

The collector, recognizing that the plant may concentrate the sought-after constituent in one or more organs, will now make a special effort to obtain separate samples representing as many different parts of the plant as possible. This can be a time-consuming task and, again, is often practical only where abundant labor is available.

The preferred size of a recollection has been set at 50 lbs. as an arbitrary figure for lack of knowledge as to what amount is likely to be needed to complete the follow-up chemical work. In some cases a much smaller amount is adequate. In other cases, because of a particularly difficult fractionation procedure that is required, or because the yield of the active constituent is phenomenally low, 300 to 500 lbs. may be required. As we have gained more experience, we are better able to predict to some extent the amount of material likely to be required. For example, we now know that certain tumor systems are sensitive to some types of compounds that have no future as anticancer drugs. We now have some basis for predicting the nature of the activity and can limit collections of such plants to small amounts of as little as 5 lbs., just enough to verify that activity will be due to one of these substances. On the other hand, if the activity is against a tumor system that is not sensitive to these compounds with a low drug potential, and if the active plant is a member of a group that is a known source of pharmacologically active compounds, then a special effort is devoted to the procurement of a minimum 50-lb. sample; and, if conditions permit, a much larger sample is obtained.

Isolation and Characterization of Active Chemical Constituents

The recollections of confirmed active plants are forwarded to laboratories specializing in the chemical fractionation, isolation, and identification of active chemical components. These

plants are being studied in about 35 laboratories, some of which are working with 50 or more species. Some of the larger participants are the Central Drug Research Institute (India), where the work is under the direction of Dr. M. L. Dhar; the Commonwealth Scientific and Industrial Research Organization (Australia), under Dr. C. C. J. Culvenor; the John L. Smith Memorial for Cancer Research in Maywood, New Jersey, under Dr. J. D. Johnston; the Research Triangle Institute, Durham, North Carolina, under Dr. M. E. Wall; the University of Arizona College of Pharmacy, under Dr. J. R. Cole; and the University of Wisconsin School of Pharmacy, under Dr. S. M. Kupchan (now continuing this work at the University of Virginia).

A recollection of a confirmed-active plant must first be tested to determine if it has the same cancer-inhibiting capability as the original active sample. An extract, identical with the first, is tested in a dose response experiment like the second and third tests employed in routine screening. If the new extract duplicates the original anticancer activity, chemists begin a systematic separation of the many and diverse chemical components present in the plant to isolate in pure form the agent responsible for the activity.

Fractionation of a crude extract to isolate a pharmacologically active compound takes advantage of the unique physical and chemical properties of the substances present in the extract. By different chemical and physical techniques, the myriad of substances can be separated into groups or fractions with similar characteristics.

Simple preliminary fractionation is accomplished, for example, by separating a crude extract into non-tannin and tannin fractions by precipitation of the latter with caffeine, or by treating a crude extract with different solvents to dissolve out compounds soluble in each. After each separation the fractions produced are bioassayed to determine which fraction contains the active agent. Active fractions are then subjected to further separation techniques. Chromatography, which relies largely on the differential adsorptive power of an adsorbent for different chemical substances, is one of the most powerful of such techniques that are available to the chemist involved in isolation of natural products. It is capable of separating substances with the most subtle differences in their physical properties.

Isolation of pure crystalline active compounds is rarely a simple task and may be extremely complex. Isolation of one or two active compounds from a typical plant source frequently requires the separation of the crude extract into about 50 fractions. The isolation of a large number of compounds from a source plant may require 500 or more separate fractions, each of which must be bio-assayed. An active constituent may amount to as little as 0.01% of the dry weight of a source plant.

Once a pure crystalline compound is isolated, its chemical structure must be determined and the task of the chemist may become extremely difficult. Chemical characterization is essential for several reasons. First, the compound may be

Fig. 10. Drying and bagging samples at the Kakamega Forest Station. Voucher specimens are in plant presses at left.

identical with an active material obtained from another source, and duplicate effort in further evaluation of the compound may be avoided. Secondly, once the structure is known, the chemist can subject the material to techniques that may accomplish minor modifications in its chemical structure that may increase activity or solubility, improve therapeutic index (ratio between the maximum dose that is tolerated and the minimum dose that is effective), or decrease unde-

sirable side effects. Thirdly, a judgment of the feasibility of its synthesis can be made, possibly leading to its economical production on a large scale. Finally, it is important to be able to recognize the relationship between the compound's biological activity and its chemical structure. Once the structural features responsible for the activity are known, the synthetic chemist can design synthesis of totally new compounds combining these features with other basic types of molecules to develop new active structures.

Preliminary clues to the nature of the compound are provided by standard chemical analysis to determine the elements present and their proportion; by qualitative tests for alkaloids, glycosides, steroids, and other classes of compounds; and by the avenues followed during the isolation and purification of the compound. Chemical characterization of the compound may be fairly simple if it was previously described and an authentic sample is available for comparison by physical methods like melting point, optical rotation, and infra-red absorption spectrum. If the compound is new, and especially if it represents a new or unusual class, highly complex and sophisticated techniques may be required. Mass spectrometry, nuclear magnetic resonance, and single crystal X-ray analysis, among other techniques, determine the number of each kind of atom in the molecule and the position of each in relation to the others.

Preclinical Pharmacology

After a pure active compound is isolated and, sometimes, even while its structure is being determined, the potential new drug is tested in a broad array of animal tumor systems, to determine its spectrum of activity and to gain as much additional information as possible. "Schedule dependency studies" are instituted to determine the effect of different doses, and frequencies and routes of administration. All information about the compound is then reviewed by committee to reach a decision as to whether further evaluation is justified. Many factors are considered: Is the substance active against animal systems that are sufficiently predictive for clinical activity in man? Does it have a sufficient therapeutic index to suggest it may be safe for clinical use? Does it represent a new kind of structure never before evaluated, or is it just one more of a class already well represented by compounds previously evaluated or under consideration? If the compound meets the necessary criteria, it is approved for preclinical pharmacology.

Predictions as to many of a new drug's possible adverse side effects when used clinically (i.e., nature and degree of toxicity or organ damage) can be based on tests in dogs and other animals. This is the primary objective of preclinical pharmacology. These studies are also geared to determine appropriate starting doses applicable to administration of the drug to human patients, the most suitable vehicle, and the most acceptable route of administration. Drugs that meet the necessary criteria are cleared for preliminary clinical trial in human patients.

Large Quantities of Drugs Required For Clinical Trial

Before clinical trial can begin, an adequate supply of the new drug must be available to assure that the preliminary clinical evaluation of the drug can be carried through to a significant conclusion. In some cases the supply situation is so critical that a special procurement effort must be undertaken in order to supply adequate amounts for preclinical research.

Several procurement avenues are open to obtain an adequate supply, and all are carefully compared to determine which is the least costly in terms of both time and financial resources. Some such compounds occur in the plant, or in another species, in sufficient abundance that they can be isolated from their natural source. Such was the case of the new drug lapachol. Its activity was detected by screening the roots of an Indian tree, in which it is present in small amounts. A review of the literature revealed that it was much more abundant in lapacho wood (*Tabebuia* spp.) of Central and South America. Other compounds occur in such minute amounts in the plant source that synthesis, when possible, is likely to be the most economical source. Such is the case of camptothecin, a promising new alkaloid of *Camptotheca acuminata* Decaisne. It appears that a practical synthesis of camptothecin is likely to be accomplished, and an intensive effort is now being made to produce it synthetically.

Still other compounds appear to be difficult of ready synthesis with the knowledge and techniques now available and will probably have to be isolated from the natural source. Harringtonine, a new alkaloid isolated from *Cephalotaxus harringtonia* (Forbes) K. Koch, and now cleared for preclinical pharmacology, is a good example. Fortunately, the substance occurs in the plant in fairly large amounts though the plant grows so slowly that production of adequate amounts of raw material may prove costly.

Fig. 11. Drying plant samples at the Forest Station, Londiani, Kenya.

Search For Better Sources of Drugs That Cannot Be Economically Synthesized

When large recollections of confirmed-active plants are prepared, the plants are routinely separated into as many samples as possible. Subsequent bio-assays of these fractional samples will indicate which part of the plant is the best source of the activity. Later sampling, as more material is needed, is designed to contribute as much new information as possible. Little additional effort can be devoted routinely to most of the active plants, for their number is large and most are active against tumor systems with relatively low clinical predictability.

Some of the active plants produce potential new drugs that will be impractical to synthesize. These merit special attention to improve future sources of supply, especially if they are active against LE or, if active against a system of lower priority, they have reached an advanced research stage and appear destined for clinical trial.

The anticancer alkaloid thalicarpine was isolated from roots of *Thalictrum dasycarpum* Fisch. & Lall., where it is present in a small amount. It does not occur in the stems or leaves in an amount sufficient to justify isolation. The plant is abundant in Wisconsin and nearby states. If the alkaloid becomes a useful drug, the quantity of roots needed will be so great that the plant will soon become rare. The fruit produce several times as much alkaloid as the roots. This perennial produces a heavy crop of fruit; it is evident that, over a period of years, a planting or natural stand will produce as much fruit as it will roots.

A large supply of *Thalictrum* seed was obtained from natural stands during the 1969 field season and preliminary research to establish a crop will be initiated in 1970. The crop potential of this plant is enhanced by its production of a seed oil with potential large-scale industrial use.

The active agent taxol was isolated from bark of Pacific Yew (*Taxus brevifolia* Nutt.). Bio-assay of a series of bark samples from different locations from Idaho to California, north to Alaska, indicated that yield of taxol fluctuated considerably. The bio-assay data provided a valuable guide when large-scale procurement was undertaken to provide 2,500 lbs. of bark for isolation of a large supply of the drug.

Assay of other samples of *T. brevifolia* indicated that taxol does not occur in detectable amounts in other parts of the plant. This yew is a small, slow-growing tree. It is abundant but the

Fig. 12. The animal for the Walker 256 test, the non-inbred albino rat, is injected in the right hind leg with 0.2 cc of a suspension of Walker cells. Ten to 12 days later the tumor usually weighs 5 to 7 grams.

bark will not be a suitable source because the yield of the drug is very low. During the past few years samples of all yew species have been asayed. No data are available to compare yields of taxol but it is evident that all species produce this compound. Should a large-scale need for this substance develop, an intensive selection and breeding program could be directed toward development of faster-growing higher-yielding types.

Extracts of *Camptotheca acuminata* demonstrated confirmed activity against LE in 1962. Intensive chemical and biological research has been focused on this plant since that time. Camptothecin, the principal active alkaloid of this species, is now in preliminary stages of clinical trial.

The tree was introduced from China. In 1962, it was rare in the United States, the total supply amounting to less than 30 specimen trees, most of which were not more than about 15 years old. A small-scale research and production program was undertaken at the USDA Plant Introduction Station, Chico, California, in late 1963. Both research and production expanded gradually during the next few years.

When the structure of camptothecin became known and it was evident that a practical synthesis was likely, agricultural research tapered off. But production has been greatly expanded and, by the spring of 1970, about 15,000 plants will be established in field plantings. These plantings will provide a supply of camptothecin for clinical research until the natural source is replaced by a practical synthesis.

Current agricultural research is minimal but production plantings are under close observation, to detect possible insect or disease problems, and to select individual plants with exceptional vigor or that are good producers of seed. During the spring of 1969, a single seedling with exceptional vigor was selected from a population of 5,000.

Camptotheca grows rapidly and can be adapted to production as a crop if synthesis eventually proves impractical. During August and September 1969, 5,800 lbs. of roots and stems were harvested to provide more of the drug for clinical research.

Plants were removed from alternate rows of two plantings of different age. It appears that the reduced competition will spur growth of the remaining plants to such a degree that the total amount available from these plantings will be at least as great a year later as the amount present during the recent harvest.

In the case of some active plants, a combination of unfavorable factors makes the original plant hopeless as a source of the drug. Such is the case with *Holacantha emoryi* Gray, native to deserts of southern California, Arizona, and northern Mexico. The plant is uncommon and its active constituent is present in very small amounts. Though the plant might grow more rapidly under irrigation, it appears to be a very slow-growing shrub.

The chemical literature, however, reveals that seed of another plant produce significant amounts of a substance that can be chemically converted to the active compound isolated from *Holacantha*. The seed of this plant are used industrially as a source of edible oil and will assure an economical source of the potential new drug.

Clinical Trial

Clinical research is a medical matter beyond the scope of this discussion. It should be noted, however, that the efficacy and safety of a new drug must be demonstrated in human patients before it can be accepted for general use.

Five to 10 new drugs are accepted for clinical trial each year. So far, these have been largely synthetic or fermentation products. Six drugs of plant origin have reached this stage.

A drug is acceptable for clinical trial only after preclinical research establishes that there is a reasonable promise that it will be beneficial to the patient, and that any possible adverse side effects can be countered by known medical means or will be offset by an overall improvement in the patient's well-being. Testing of a new drug at this stage is limited to patients with advanced disease.

Classes of Active Chemical Agents

The search for anticancer agents turned to plants because of the known chemical diversity of this resource. It was hoped that this quest would not only yield a diversity of plant products of potential drug value, but would also provide clues to new types of pharmacologically active chemical structures, and thus broaden the opportunities of chemists attempting to synthesize a broader array of substances with anticancer activity.

This search has been rewarded with numerous new pharmacologically active substances of great chemical diversity. Many are novel chemical types. Most would not otherwise have been available for consideration, either because they are difficult to synthesize, or because, lacking prior knowledge of their potential activity, there would be no logical reason to attempt synthesis.

The discovery of a new class of chemical compounds capable of inhibiting cancer growth is of great value even though the initial representative compounds may prove unsuitable for clinical trial. Each such discovery offers the promise that other more suitable representatives of the class will be isolated from other plants, or result from synthesis or chemical modification of the plant product.

The potential drug value of the classes of compounds discussed below varies from those with little if any future to some with considerable promise. Compounds representing one of the latter groups appear better than did certain clinically established drugs when they were at the same preliminary stage of development.

Alkaloids. The most promising group of new anticancer agents, in number and variety, is the alkaloids. These substances are widely distributed in the plant kingdom though many are concentrated in such families as Apocynaceae, Papaveraceae, Leguminosae, and Ranunculaceae. As a group, they are well-known for their pharmacological activity and play an important role in modern medicine. They are very diverse, indeed so diverse that they defy simple definition. Collectively, the alkaloids are active in a broad spectrum of animal tumors; several are active against LE.

Cucurbitacins. These are highly toxic substances, isolated largely from species of Cucurbitaceae. Recently, they were also isolated from

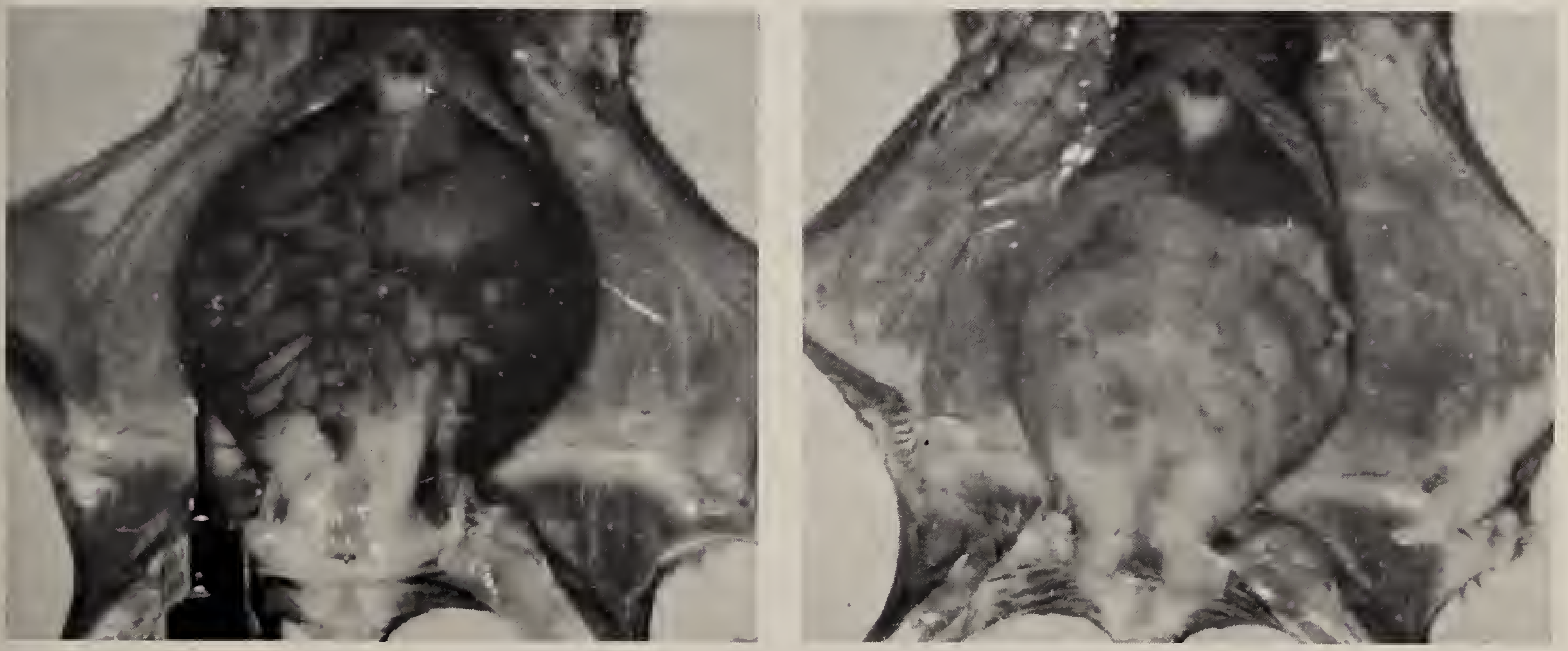

Fig. 13. The L-1210 test system uses strains of especially bred mice. The photos above show the contrast between the distended, darkened abdomen of the leukemic animal from which fluid is being removed with a syringe (left) and the normal mouse (right). The fluid will be diluted for use in other tests.

species of Cruciferae, Scrophulariaceae, and Begoniaceae. These compounds are highly active in KB but have little *in vivo* activity, and, hence, offer little promise.

Diepoxides. Crotepoxide, isolated from the Ethiopian tree *Croton macrostachys* Hochst., is an unusual member of this group of compounds which is represented by a considerable number of synthetics that have shown good activity. Crotepoxide does not have sufficient activty to justify further evaluation, but it is of importance because it is the first diepoxide with anticancer activity to be found in a plant. This suggests that other more suitable compounds of this type may be found.

Digitaloid glycosides and their aglycones. A large number of compounds of this group, including cardenolides, bufadienolides, and withaferins, have been active, especially against KB. A few show activity against *in vivo* tumor systems, but their therapeutic indices are too low to justify further evaluation. This class of compounds is of considerable interest, nevertheless, because it is abundant in nature and few members have been considered.

Lignans. The activity of a large number of extracts from such distantly related genera as *Juniperus, Podophyllum,* and *Bursera,* all active in KB, has proved to be due to lignans. These substances had been considered to have no promise because they are active largely in KB and show only very low activity in *in vivo* tumors. More recently, two new lignans were isolated from a species of *Bursera* which are active in WM. One of them looks sufficiently interesting to justify further evaluation.

Phytosterols. Ligroin extracts from a considerable number of plants were active against WM. Fractionation established that activity was due to sterols, frequently to beta-sitosterol, a substance almost ubiquitous in the plant kingdom. An effort was made to develop this compound, but beta-sitosterol and its active derivatives are unsuitable because of poor solubility and low therapeutic index. The phytosterols are presently of little interest.

Proteins. Proteinaceous materials have been isolated as the active cancer-inhibiting constituents of a considerable number of plants. One, isolated from seed of *Caesalpinia gilliesii* (Hook.) Wall. ex Loefgren, is scheduled for preclinical pharmacology. It was selected from several such materials available because it shows very good activity against WM, and was available in purest form and in adequate amount.

Quinones. Several quinones have been active. The most notable is lapachol, now in clinical trial. It was isolated in small amounts as the active constituent of roots of the Indian tree *Stereospermum suaveolens* DC. A better source is lapacho wood (*Tabebuia* spp.) of tropical America in which it is comparatively abundant. In Brazil, a tea prepared from *Tabebuia* spp. is widely used both by physicians and in folk medicine for treating cancer. This compound is unusual in that it is more active when administered orally than when administered intraperitoneally to experimental animals.

Saponins. These compounds are also widely dispersed in the plant kingdom. A considerable number have shown activity, especially against WM. The most interesting is *Acer* saponin P, which has the largest therapeutic index in WM of any active compound in this group. It is undergoing further investigation and will probably be considered for clinical trial.

Sesquiterpene lactones. These active compounds were isolated largely from plants of the family Compositae. Much of the activity of plants of this family appears to be due to this class of compounds. Most of the active sesquiterpene lactones are active only against KB; a few are active against WM but have a therapeutic index too low to justify further study.

Tannins. These substances are very widely distributed in higher plants, especially in the woody species, and are responsible for the anticancer activity of many crude extracts. They are active especially against WM; only rarely are they active against KB. Tannins are consistently highly toxic with low therapeutic indices. Since they are also difficult to purify and are chemically unstable, they are considered to have little if any promise. Methods are followed early in the fractionation procedure to identify plants with activity due to tannins, and such plants are dropped from the program.

The following tables list anticancer agents isolated from plants that have reached preclinical pharmacology or a more advanced stage and are still under consideration for further evaluation.

AGENTS APPROVED FOR OR NOW UNDERGOING PRECLINICAL PHARMACOLOGICAL EVALUATION

Agent	Class	Source Plant	Origin of Plant
harringtonine	alkaloid	Cephalotaxus harringtonia (Forbes) K. Koch (Cephalotaxaceae)	horticultural sources in U.S. and Italy (native to Japan)
ellipticine	alkaloid	Excavatia coccinea Markgraf (Apocynaceae)	New Guinea
		Ochrosia moorei F. v. Muell. (Apocynaceae)	Australia
dl-tetrandrine	alkaloid	Stephania hernandifolia Walp. (Menispermaceae)	India
d-tetrandrine	alkaloid	Cyclea peltata Hook. f. & Thoms. (Menispermaceae)	India
Acer saponin P	saponin	Acer negundo L. (Aceraceae)	Wisconsin and Utah
uncharacterized protein	protein	Caesalpinia gilliesii (Hook.) Wall. ex Loefgren (Leguminosae)	Arizona

Distribution of Anticancer Activity In Higher Plants

During the past 12 years, about 45,000 crude extracts of higher plants have been screened. About 1,400, representing some 1,200 species, have shown reproducible activity in one or more of the tumor systems used in the screen. The active species represent 158 families.

It soon became evident that there were concentrations of activity in some families, but the broad spectrum of activity (in 158 of 270 families represented) was puzzling. It is now evident it is due to the sensitivity of the tumor test systems to a large number of classes of chemical compounds, some of which are very common and others of which are almost ubiquitous in the plant world.

Active constituents have been isolated from some 240 species. The activity of 35% of these plants is due to tannins; the activity of 10% is due to phytosterols; and the activity of 55% is due to other classes of compounds.

It is evident that, because of the large proportion of activity due to substances with little if any

AGENTS APPROVED FOR CLINICAL EVALUATION

Agent	Class	Source Plant	Origin of Plant
thalicarpine	alkaloid	Thalictrum dasycarpum Fisch. & Lall. (Ranunculaceae)	Wisconsin
acronycine	alkaloid	Acronychia baueri Schott. (Rutaceae)	Australia

AGENTS NOW UNDERGOING CLINICAL EVALUATION

Agent	Class	Source Plant	Origin of Plant
camptothecin	alkaloid	Camptotheca acuminata Decaisne (Nyssaceae)	botanical gardens in U.S. and Taiwan (native to China)
lapachol	quinone	Stereospermum suaveolens DC. (Bignoniaceae)	India
		Tabebuia spp. (Bignoniaceae)	Central and South America
emetine	alkaloid	Cephaelis ipecacuanha (Brot.) Rich. (Rubiaceae)	Central and South America

potential drug value, the distribution of general anticancer activity in higher plants is largely academic. But the distribution of potentially useful activity, due to compounds other than tannins and phytosterols in particular, is of considerable practical importance.

When screening demonstrates that a family or other group is a rich source of activity, the question now arises as to whether or not the activity is due to potentially useful compounds. We are beginning to reach the point where we can predict with some confidence that certain families are very unlikely to yield useful drugs, while others can be recognized as especially promising. Currently, routine procurement is still conducted completely at random, and no family is excluded. But leads to promising sources of activity are being followed up with intensive procurement efforts to locate additional genera and species of impressively active groups.

The anticancer activity of the first 10,000 samples procured by USDA was reviewed to establish guidelines that might be applicable to future procurement. These samples represented 5,478 species in 2,073 genera and 206 families; 11% of the species tested were active and 20% of the genera had at least one active species.

The conifers are the richest source with activity shown by 34% of the species and 57% of the genera tested. Active agents have been isolated from less than half of the active species, but already this group has yielded a considerable diversity of active agents. One is expected to represent a class of chemical compounds that is unique in the program. The most promising are the LE-active alkaloids of *Cephalotaxus* and *Taxus.*

Activity of plants of the order Magnoliales has also been impressive. Twenty-three percent of the species tested were active and 30% of the genera tested were represented by at least one active species. Most of the anticancer agents isolated from this group are alkaloids. The Magnoliales are a well-known source of alkaloids; this, in combination with a good concentration of KB activity in this order, suggests that the activity of many other species is most likely due to alkaloids and unlikely to be due to tannins or phytosterols.

A family with many active species is the Liliaceae. We have screened about 70 of the 250 genera, and 25 genera now have at least one active species. Few active agents have been identified from this group but the family is a well-known source of alkaloids.

Some other promising families with high levels of activity in which the activity appears to be due to substances other than tannins and phytosterols are: Asclepiadaceae, Apocynaceae, Solanaceae, and Ranunculaceae.

Other families have an impressive number of active genera and species, but appear to have little promise as sources of useful drugs because of the nature of the agents responsible for the activity. The activity of almost all species of Cornaceae, Ericaceae, Fagaceae, Onagraceae, Polygonaceae, and Rosaceae is due to tannins. The activity of the Cucurbitaceae is due primarily to the cucurbitacins. The yield of active species of Compositae is equivalent to the average for all families, but the number of active species is high because of the large number of species of this family included in the program. A large proportion of the activity in this family is due to sesquiterpene lactones.

In summation, it is evident that the search for plant sources of anticancer drugs must be a long-term program. It was only recently that a sufficient number of plants had been screened, and enough had been learned about the chemical structure of their active components, that new avenues can be opened, leading to an even more profitable program. Concomitantly, clinical experience, largely with synthetic compounds, has provided valuable feedback in that it has pointed out the experimental tumor systems with greatest clinical predictability and has permitted improvements in the screen. This process of developing a truly predictive screen is at the heart of the whole effort to produce useful anticancer drugs and is continuing. As the screen improves, the nature of the isolated compounds of greatest interest is likely to change, and an increase in the proportion of useful compounds is to be expected.

A long-term research effort, directed toward a specific but distant goal, must be evaluated at any point in time by what has been accomplished in relation to what is reasonably expected at each stage. The search for anticancer agents of plant origin has so far been judged successful at each stage through which it has passed. The ultimate judgment must await the final clinical evaluation of drugs headed in that direction.

Selected References

Anonymous. Progress Against Cancer 1969, A Report by the National Advisory Cancer Council. U. S. Department of Health, Education, and Welfare. 83 pp. (1969).

Farnsworth, N. R. Biological and Phytochemical Screening of Plants. Jour. Pharm. Sci. 55: 225-276 (1966).

Hartwell, J. L. Plants Used Against Cancer. A Survey. Lloydia 30: 379-436 (1967); 31: 71-170 (1968); 32: 79-107, 153-205 (1969); continuing.

Hartwell, J. L., and B. J. Abbott. Antineoplastic Principles in Plants: Recent Developments in the Field. Advances in Pharmacology and Chemotherapy. Vol. 7. In press.

Perdue, R. E., Jr., *et al. Camptotheca acuminata* Decaisne (Nyssaceae) - Source of Camptothecin, an Anti-leukemic Alkaloid. U.S. Department of Agriculture Technical Bulletin. In press.

Venditti, J. M., and B. J. Abbott. Studies on Oncolytic Agents from Natural Sources. Correlations of Activity Against Animal Tumors and Clinical Effectiveness. Lloydia 30: 332-348 (1967).

Zubrod, C. G., *et al.* The Chemotherapy Program of the National Cancer Institute: History, Analysis, and Plans. Cancer Chemotherapy Reports 50: 349-540 (1966).

The Search for Anti-tumor Agents Among the Higher Fungi[1]

Marlin A. Espenshade

Fig. 1. Sporophores of a species of Basidiomycetes.

Fig. 2. Removing samples from which cultures will be made.

The contributions of woody plants to medicine have been varied and extraordinarily important. The discovery of quinine alone would have provided ample precedent for the search for plants that manufacture compounds that would be useful in the treatment of other grave afflictions of man. Such materials, like quinine, might very well be formed in extremely low concentration in restricted parts of the woody plant. Nevertheless, the need is so compelling that the search continues.

If we broaden our concept of crop and farm, however, the possibility of discovering a *microorganism* that forms a rare chemical becomes most enticing. First, as has been abundantly demonstrated in penicillin production, the farm could be a "three-dimensional" one. Instead of vast acreages of fertile soil, it would be a tall tank containing several thousand gallons of aerated, agitated culture medium. Such tanks can be housed indoors or out and occupy a relatively small area.

But is space the most important thing? Time is even more important when we consider the value of an anti-tumor compound. Ordinary crops are harvested once a year, at the end of the growing season. Vats of microorganisms can be harvested every 4 to 7 days, as in antibiotic production.

Exploring the use of a fungus, as for example, a Basidiomycete, has additional appeal because the active compound can be sought in two places: the liquid in which the fungus grows and the fungus itself. Extracting material from either of these can be much easier than extracting minor constituents of tough, woody tissues or of leaves.

The yields of tissue per unit time and space are enormous in antibiotic production. As many as ten tons of fungus have been harvested in less than a week from a twenty-thousand-gallon tank. There is every reason to believe that methods for obtaining similar yields of tumor-retarding fungus could be developed. This potential for yield increase has characterized industrial microbiology virtually from the beginning. It had long been known that the yields of various fungal metabolites could be altered greatly simply by altering the composition of the culture medium. Similarly, it had long been known that most fungus species exist in a rich array of physiologi-

[1] Part of the investigations mentioned were supported by Cancer Chemotherapy National Service Center Contracts No. SA-43ph-3073 and PH-43-63-1121, National Cancer Institute, Public Health Service.

cal races, differing from one another in significant ways. The variants originate in many ways including mutation, recombination of heritable material in purely asexual manner, parasexual recombination, and sexual recombination.

The demonstration that ultraviolet light treatment could greatly increase the number of recoverable mutant forms of fungi came at a time that permitted the exploitation of the technique in many new microbiological industries. Such experimentation has resulted in increasing the yield of penicillin from 80 units per ml of "farm" in 1943 to more than 10,000 units at present. This is an increase of one hundred twenty-five-fold in the course of only a quarter century. To be sure, the total production of penicillin has increased even more during the short life of the industry, but we are here concerned with yield improvement rather than total production. The total production of wheat and potatoes in the United States is enormous, but the average per acre is not so spectacular. The national average for wheat in 1900 was 12.2 bushels per acre; by 1964, it had slightly more than doubled (25.2 bushels). Potato yields for the same period went from 51.9 hundredweight to 185 hundredweight per acre. Of course, these are two examples of ancient crops that undoubtedly underwent a rapid improvement of yield in prehistoric times, if only when wild types were first aggregated in tilled plots. Nevertheless, the genetic stability of green plants, as well as their long generation times reduce the likelihood of increases of the order of magnitude found in industrial microbiological processes. Nor is the yield of the conventional crop likely to approach that already possible for fungal mycelium (several hundred tons per year per tank). So then, in view of the efficient use of space, the number of harvests per year, and the pliability of the organism itself, the discovery of a fungus that would show even slight anti-tumor activity would be important.

The Basidiomycetes were selected for study because they have not been investigated to the extent that some of the Streptomycetes, Phycomycetes, or the Fungi Imperfecti have. To those groups belong most of the microorganisms used industrially to manufacture organic acids, antibiotics, and special steroids. Details of the metabolism of the more slowly growing Basidiomycetes have been somewhat neglected. *Agaricus bisporus* has been cultivated for food and there are even a number of patents covering the cultivation of mycelium in tanks for food production, but Basidiomycete metabolic products,

Fig. 3. Collecting spores of a mushroom.

their influence on other organisms, and their effects against pathogens of man have not been investigated in nearly as great detail as with the molds mentioned above. Admittedly there would be problems—problems of slower growth rate, of nutrition, of extraction, of assay—but one other interesting facet of the Basidiomycetes was of such overwhelming significance that a major project was in order.

A modern scientist, E. H. Lucas, turned up some interesting folklore of the lumberjacks of the Bohemian Forest along the border between Germany and Czechoslovakia. The "Steinpilz", *Boletus edulis* (Bull.) Fr., highly valued for food the world over, was believed to prevent cancer. As a consequence, some of the mushrooms were collected, dried, extracted with water, and tested against Mouse Sarcoma 180. The extract was

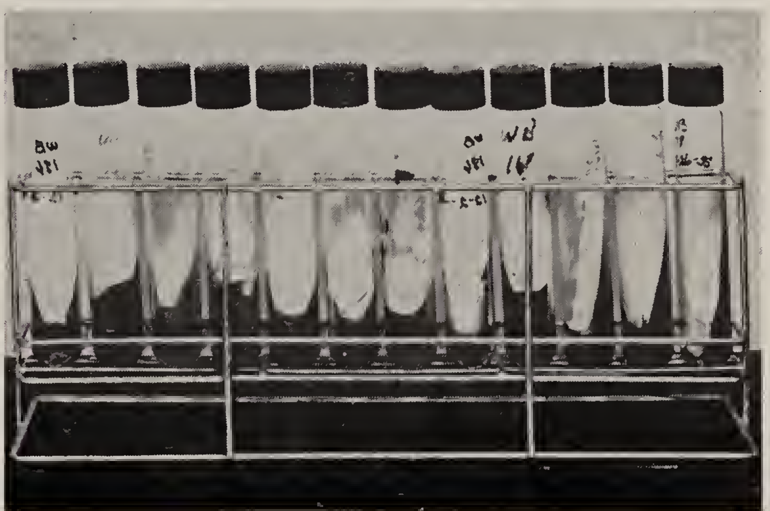

Fig. 4. Cultures of Basidiomycetes growing on solid nutrient media.

Fig. 5. Microscopic view of fungus mycelium growing on a solid medium.

active. Attempts then were made to culture the fungus and to obtain the active material, a polypeptide, from fresh tissue. Bad news: the fungus grew slowly; the new tissue was inactive. Nevertheless, the discovery led to further examination of the active material and to the initiation of additional searches among the Basidiomycetes. In addition to two more mushrooms, it was found that the puffball *Calvatia gigantea* (Pers.) Lloyd with which there was also folklore associated, forms a highly active tumor-retarding material (calvacin) in the immature sporophores. Needless to say, investigations increased in number and intensity. Extracts of three additional puffballs are also active. More important, calvacin, a mucoprotein, was formed by *C. gigantea* in submerged liquid culture. Research in culture technology and strain selection advanced even while purified calvacin was evaluated with additional tumor systems and with additional animals. Unfortunately, the adverse allergenic characteristics noted in dogs after prolonged treatment were also noted in clinical trial and the compound was dropped.

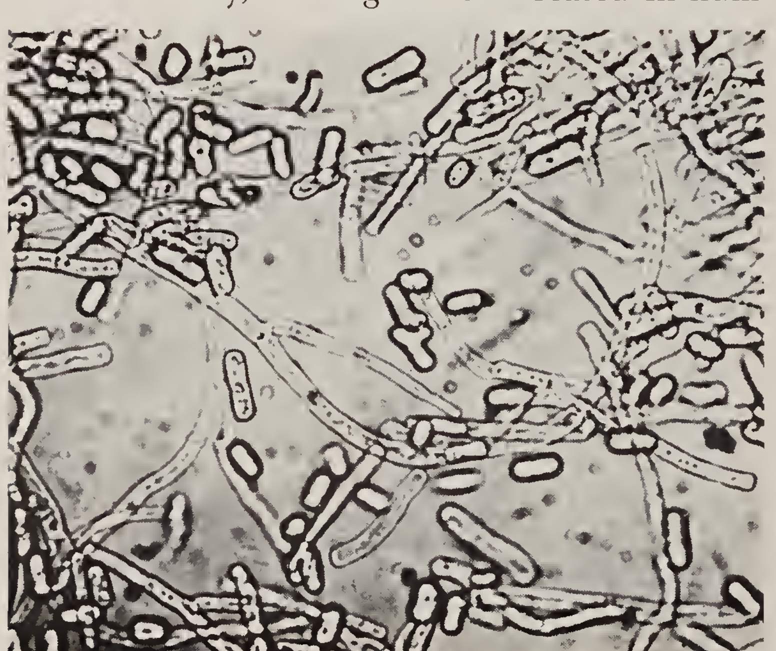

Fig. 6. Microscopic view of fungus mycelium from a liquid medium.

Those early studies with the fungi nevertheless had provided three incontrovertible facts: 1) Powerful tumor-retarding compounds are formed by some Basidiomycetes. 2) Higher fungi can be cultured on an industrial basis. 3) The yield of tumor retardant can be improved by conventional strain improvement methods. The Cancer Chemotherapy National Service Center of the National Institutes of Health arranged to step up the tempo of the search even more.

With the *Boletus-Calvatia* folklore and the research of Lucas, Beneke, and associates as background, the decision was made to assay as many representatives of as many genera and families as possible each year. The three time-consuming live mouse tumor assay tests (Sarcoma 180, Mammary Adenocarcinoma 755, Leukemia 1210) would be the main limitation imposed on the number to be included in the program. Some 7000 evaluations of broths and extracts from fungal tissue were made over a period of several years.

The fungi were obtained from several sources. Some came from living culture collections maintained in laboratories in various parts of the world. These could be processed first. At the beginning, relatives of *Boletus* and *Calvatia* were given priority. Other fungi were collected from the wild. This was one of the more interesting aspects of the investigations, because it meant not only searching for the fungi in their natural habitats, but obtaining uncontaminated cultures from them as promptly as possible (Figs. 1-4). Either spores or bits of tissue were taken from the mushrooms for transfer to a variety of sterile, solid culture media. The remainder of each collection was dried and preserved for future identification. Sometimes the cultures were started in the field; others were made from a day's collection after returning to the laboratory. Freezing of the fungi or overnight storage decreased the possibility of obtaining pure cultures. The major collecting areas were along the Eastern Seaboard and in the Midwestern states.

TABLE 1.: Respiration of Coprinus sphaerosporus on Medium #28 (4)

DAYS	RR (ppm/hr.)*	pH
3	< 5	5.7
4	6	5.9
5	13	6.0
6	24	6.1
7	45	5.7
10	58	7.8
11	7	8.6
12	5	8.6
14	5	8.6

*Respiration rate by a polarographic method for rate of oxygen uptake.

As soon as a fungus was brought under cultivation three lines of endeavor began. The first was simply to keep the organism alive while testing proceeded. The second was the maintenance of strict records, and the third was the cultivation, in some kind of liquid medium, of sufficient quantity for tests of both mycelium and broth with the mouse tumor systems. The fungi were maintained on solid media in tubes (Figs. 4, 5). Transfers were made to fresh tubes from time to time and to solid media in culture dishes so that material would always be available for starting new cultures for tests.

TABLE 2.: Respiration of Tricholoma panaeolum on Medium #43 (4).

DAYS	RR (ppm/hr.)	pH
3	3	5.4
7	5	5.5
9	11	5.6
10	22	5.6
14	70	4.9
16	52	5.1
18	49	5.2
21	47	6.8
23	34	6.5

*Respiration rate by a polarographic method for rate of oxygen uptake.

TABLE 3.: Respiration of Poria corticola on Medium #66 (5).

DAYS	RR (ppm/hr.)*	pH
2	15	5.9
6	57	7.3
7	85	7.3
8	39	7.5
9	15	7.7
10	< 5	8.0
13	< 5	7.9

*Respiration rate by a polarographic method for rate of oxygen uptake.

Growth characteristics peculiar to each of the hundreds of species gradually emerged as attempts were made to obtain a harvest from liquid media. Bits of mycelium were transferred to a standard medium in a series of flasks. If sufficient growth had occurred after 10-15 days, the mycelium was separated from the broth (Fig. 6). As might be expected, not all of the fungi would grow on the same medium or be ready for harvest in 15 days. If some growth had occurred, the cultures could be processed later, but if there were none, a new formula was tried. Before this phase of the program was over, a hundred or so different media had been employed.

As active fungi were discovered, a series of increasingly detailed investigations began. First, the entire procedure was repeated to confirm the activity. Next, attempts were made to learn something about the cultural behavior of the fungi that would be useful in recognizing other active fungi or in predicting the best harvest time in large-scale fermentations. Likewise, attempts were made to find a correlation between performance in several simplified tests with performance in the time-consuming live animal tests so that activity could be predicted more easily. Finally, large-scale fermentations were undertaken so that chemical purification and advanced anti-tumor tests could proceed.

The cultural behavior of several active fungi was examined in regard to changes in pH and respiration rate during culture (Tables 1-3, Fig. 7). It is clear that the peak activity of cultures of different fungi is reached at various times, that the rates of respiration may differ radically, and that metabolic activity may persist for varying times after the maximum rate has been attained. By changing only the acidity of the medium the time of greatest respiration may be hastened or delayed. Metabolic studies of one of the promising fungi, *Poria corticola* (Fr.) Cke., revealed that the concentration of the actual tumor-retardant chemical, poricin, was highest one day after the sugar in the medium had been depleted. The same investigators found that poricin moved from the mycelium to the broth (undesirable) later still. Thus, one simple procedure, the daily monitoring of glucose, permitted the accurate establishment of best harvest time and, in consequence, culture volume increases from the 0.1-0.15 liter of early experiments to 90 liters were facilitated.

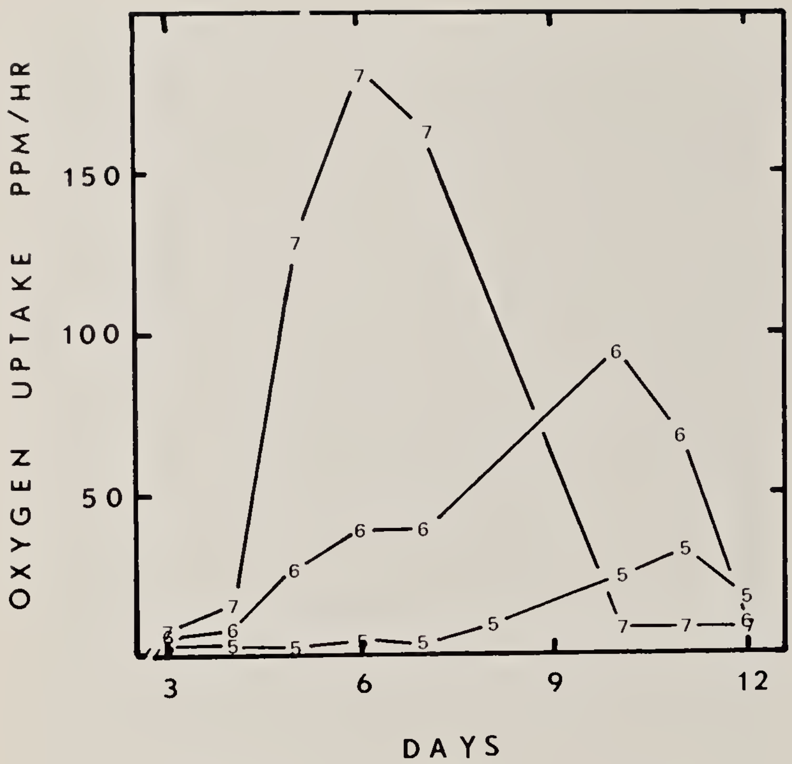

Fig. 7. The effect of pH of culture medium on oxygen consumption of *Coprinus sphaerosporus*. Figures on the curves refer to the pH at the beginning of the experiment.

The indications of variation in metabolism among fungi that form anti-tumor compounds have already been confirmed by what is being learned about the chemistry of the purified materials. Not all are protein, or even nitrogen-containing.

The attempts to find simple tests that would be predictive for activity in living animals failed.[2] The degree of inhibition of mammalian tumor cells growing separately from animal bodies on special media could not be correlated with test results in afflicted animals. Likewise, when active extracts were pitted against several dozen microorganisms, there was no correlation of antibiosis and tumor inhibition. This was scarcely surprising in view of the well-known fact that modern antibiotics are useless against cancers.

About 50 of the 7000 fungal preparations were inhibitory to one of the tumor systems. A wide variety of genera and families are represented, but most active cultures retarded only Sarcoma 180. Three or four species are inhibitory to Carcinoma 755; only one has been reported to be inhibitory to Leukemia 1210.

These fungi are now in various stages of development that require thousands more assays and chemical steps. There have been over 10,000 assays of poricin preparations alone. Some active agents, like calvacin and poricin, have been disappointing because of toxicity to normal tissues. Much remains to be done. Only a half-dozen of the retardant chemicals of Basidiomycete origin have been chemically characterized in any detail. Perhaps all will be too toxic for use. Even should this prove true, valuable information has been obtained that provides a basis for the synthesis of derivatives or related compounds that might combine high anti-tumor effectiveness with low toxicity for normal cells.

([2] But See Page 42.)

References

1. Beneke, E. S. 1963. Calvatia, calvacin and cancer. Mycologia 55: 257-270.
2. Block, S. S., T. W. Stearns, R. L. Stephen and R. F. J. McCandless. 1953. Mushroom mycelium experiments with submerged culture. J. Agr. Food Chem. 1: 890-893.
3. Espenshade, M. A. 1962. A study on the isolation and the cultivation of Basidiomycetes. *In* C. F. Koda (ed.). Developments in Industrial Microbiology. Plenum Press, New York. 3: 347-352.
4. ————. 1962. Mushrooms and toadstools — their growth in liquid media using deep culture techniques. Mushroom Science 5: 213-217.
5. ————, and E. W. Griffith. 1966. Tumor-inhibiting Basidiomycetes. Isolation and cultivation in the laboratory. Mycologia 58: 511-517.
6. Gregory, F. J., E. M. Healy, H. P. K. Agersborg, Jr., and G. H. Warren. 1966. Studies on antitumor substances produced by Basidiomycetes. Mycologia 58: 80-90.
7. Lucas, E., R. L. Ringler, R. U. Byerrum, J. A. Stevens, D.A.H. Clarke, and C.C. Stock. 1957. Tumor inhibitors in *Boletus edulis* and other Holobasidiomycetes. Antibiot. Chemotherapy 7: 1-4.
8. ————, R. U. Byerrum, D. A. Clarke, H. C. Reilly, J. A. Stevens, and C. C. Stock. 1958-1959. Production of oncostatic principles *in vivo* and *in vitro* by species of the genus Calvatia. *In* Antibiotics Annual, pp. 493-496. Medical Encyclopedia, Inc. New York, N. Y.
9. Perdue, Robert E., Jr. and Jonathan L. Hartwell. 1969. The search for plant sources of anticancer drugs. Morris Arboretum Bull. 20: 35-53.
10. Ruelius, H. W., F. W. Janssen, R. M. Kerwin, C. W. Goodwin, and R. T. Schillings. 1968. Poricin, an acidic protein with anti-tumor activity from a Basidiomycete. I. Production, isolation, and purification. Arch. Biochem. Biophys. 125: 126-135.
11. Santoro, T., and L. E. Casida, Jr. 1959. Improved method for obtaining vegetative growth of mycorrhizal and other slow-growing fungi. J. Bacteriol. 78: 449-450.
12. Stevens, J. A. 1957. Studies of environmental factors influencing *in vitro* growth of Basidiomycetes and their elaboration of biologically active substances. Ph. D. Thesis. Michigan State University, East Lansing, Michigan. 152 pp.
13. U. S. Government Printing Office. 1960. Historical Statistics of the United States. pp. 297, 303.
14. ————. 1968. Statistical Abstracts of the United States. p. 618.

Arboretum Activities

(Continued from page 34)

and practice in addition to experiencing some of horticulture's allied subjects. As part of many activities walks were taken through the Arboretum to show the class rare plants as well as the more commonly planted species likely to be found in a typical housing development. Many of the children were fascinated with such plants as licorice and coffee, tapioca and cinnamon, seen for the first time in our medicinal garden.

The painting of our extensive wrought iron fencing is, at last, in progress.

The Staff

This month, *Dr. Li* is completing his research assignments at the Smithsonian Institution, Washington, D. C.

Mr. Heeps presented an illustrated lecture on Plants and Gardens of California on June 9 to the Germantown Horticulture Society, and on June 12 to the National Association of Professional Gardeners. His teaching activities included a lecture for the Landscape Architecture students entitled "The Functions and Management of Arboreta and Botanic Gardens, and Their Role in Education and Research." In addition to the many other efforts required to assure the success of the Summer Program sponsored by the Pennsylvania Horticultural Society at the Arboretum, he presented two lectures, "Plants and the Seasons" and "Plants and Gardens of California and Florida." Elsewhere in the Arboretum, special attention has been given to improving the design of the Medicinal Garden and in renovating the water features of the Arboretum for the enjoyment of visitors from the 24th Annual American Horticultural Congress.

Mr. Keyser also made important contributions to the Horticultural Society Summer Program at the Arboretum with a series of three lecture-demonstrations on plant propagation. These sessions, held in the head house of the greenhouses, covered propagation by seed, cuttings, and grafts.

His long-term azalea breeding program is progressing. In addition to the crosses made in recent years, he has collected superior native forms from the wild to augment our collection of native azaleas that will serve as stock for interspecific crosses.

Mr. K. Y. Lee, Morris Arboretum Graduate Fellow, 1967-1969 recently fulfilled all the requirements for the degree of Master of Science at the University of Pennsylvania. His thesis was devoted to "Studies on the Pollen Morphology of the Family *Hamamelidaceae* Lindl."

Dr. Dahl spent the month of July at the Ames Research Center, Moffett Field, California, where the Biosatellite Centrifuge facilities were used for completing additional phases of research on "Morphogenesis in *Arabidopsis*." Another of his activities in the west was the assembling of a collection of important varieties of *Fuchsia* to augment the growing number of representatives of the interesting genus that visitors to the Arboretum may enjoy in the summertime.

A. Orville Dahl

About Our Authors

This special issue, devoted to explorations in field and laboratory for compounds that will be effective in the treatment of cancers, has been made possible through the close cooperation of our authors and the National Institutes of Health. Here for the first time since the program began, the major aspects of the search: botanical, mycological, chemical, and pharmacological, have been brought together for a general audience.

Robert E. Perdue, Jr., Ph. D. Harvard University, is a plant taxonomist whose career very early began to take him far from home. As a botanist attached to the Geologic Survey, he mapped the vegetation of a number of countries before joining the Crops Research Division. For the past several years the search for anti-cancer compounds has led him across our continent and to Formosa, Japan, and Africa. As this issue goes to press he is participating in yet another collecting trip in Africa.

Jonathan L. Hartwell, Ph. D., Harvard University, is an organic chemist who has been associated with the National Cancer Institute for thirty years. His interests in chemotherapy and the association of chemical structure with antitumor activity now encompass active agents from the plant kingdom. Since part of his administrative responsibility is to coordinate much of the natural products work, he has been uniquely able to achieve a broad view.

Marlin A. Espenshade, Ph. D., George Washington University, is a Senior Scientist in the Antibiotic Division of Wyeth Laboratories, Inc. where he has developed improved strains of *Penicillium* by methods mentioned in his article. Getting the enlarged Basidiomycete project underway, collecting, maintaining, culturing, and supplying the first extracts for tumor assay were among his responsibilities.

Morris Arboretum Bulletin

LEGES SINE MORIBUS VANAE

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Winter aspect of the creekside Metasequoia grove at the Morris Arboretum

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THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Arboretum.

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Arboretum Activities

December, 1969, after an Autumn of relatively severe frosts, has been brightened by the conspicuously profuse flowering of *Hamamelis japonica* Sieb. & Zucc. in the Hamamelidaceous section of the Morris Arboretum. The yellow, ribbonlike petals are demonstrating the remarkable cold-and frost-resistance which was noted long ago by Professor Albert Rehder.

Various repairs and renovations are being continued in the Arboretum. The badly rusted, interior framework in the Fern House is now, happily, repainted. The Gate, Miller, and Farm houses are currently in the terminal phases of painting. The long-term repainting by our cooperative staff of our extensive wrought-iron fencing is actually underway. We trust that satisfactory arrangements for long-needed dredging of the once picturesque Swan Pond can be completed before Summer, 1970.

On Tuesday, September 16, the Morris Arboretum was pleased to function as host at a luncheon and tour arranged for some 70 delegates and members

(Continued on Page 76)

Cytology of Magnolia Hybrids. I.

Frank S. Santamour, Jr.[1]

Of the many natural and artificial interspecific hybrids in the genus *Magnolia,* few have been subjected to cytological analysis. Whitaker (1933) noted slight meiotic irregularities and about 25% pollen sterility in several cultivars of the hybrid *M.* x *soulangiana* Soul. However, he counted n=38 chromosomes in the hybrids, whereas the parent species, *M. liliflora* Desr. ex Lam. and *M. denudata* Desr., are tetraploid (n=38) and hexaploid (n=57) respectively! Janaki Ammal (1953) correctly identified the *M.* x *soulangiana* hybrids as pentaploids with 2n=95 chromosomes. In addition, she made chromosome counts on a number of other hybrids but noted no details of meiosis. Santamour (1966) observed meiosis in the pollen-mother-cell of *M.* x *thompsoniana* (Loud.) C. deVos (*M. virginiana* L. x *M. tripetala* L.), and reported on meiotic irregularities leading to about 99% abortion that explains the lack of fruitfulness of this cultivar.

The lowest recorded haploid chromosome number in *Magnolia* is n=19, and all known species have chromosome complements based on this number. Ehrendorfer et al. (1968) considered x=7 as the primitive base number in woody Polycarpicae, and thus the Magnolias would be regarded as palaeopolyploids. Regardless of the ancient origin of the parent base number, the fact that gametes with fewer than 19 chromosomes are not viable (Santamour, 1966) indicates that n=19 is presently a genomic base number.

More detailed study of chromosome behavior at meiosis is necessary for an adequate understanding of the causes of the lack of fruit set in hybrids. Detailed cytological information may also be used to determine the possibilities and limitations of future breeding work with certain hybrid combinations. In addition to the above practical considerations, the knowledge of chromosome pairing and behavior in hybrids may help to explain the phylogenetic relationships among the various taxa of the genus.

This paper is a report on the cytological aspects of meiosis in three groups of hybrid Magnolias, in which the parents belong to different sections of the genus.

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M. virginiana x M. grandiflora

Artificial hybrids of this combination were first made at the U.S. National Arboretum by Oliver Freeman in 1930 and 1931 (Freeman, 1937). At the present time, the Arboretum collection includes some 25 individuals of this cross. In recent years, vegetatively propagated material of several clones has been under test at other institutions. The cultivar 'Freeman', was named and distributed in 1962; and another cultivar, 'Maryland', was named in 1967 because of its superior performance and acceptance in England.

M. virginiana L., the female parent, belongs to the section Magnoliastrum and is a diploid with 2n=38 chromosomes. Pollen abortion averaged only 2% in the two individuals sampled. Average size of the oval pollen grains was 60.8 μ x 46.6 μ (overall average diam = 53.7 μ). The male parent, *M. grandiflora* L. of the section Theorhodon, is a hexaploid with 2n=114 chromosomes. Pollen abortion was only 4%, and the grain size averaged 77.3 μ x 61.2 μ (overall average diam = 69.2 μ).

Five hybrid clones, including 'Freeman', were selected for cytological study. Flower size was intermediate between the two parents and pollen was shed normally in the laboratory. Pollen abortion, based on empty and distorted grains, ranged between 11 to 29% among the clones. In addition, another 41 to 54% of the grains were poorly stained with acetocarmine and showed minor abnormalities of grain structure. Thus, the percentage of non-functional pollen may be as high as 70 to 75%. Pollen grain size in the hybrids averaged 72.0 μ x 54.5 μ (overall average diam = 63.3 μ); intermediate between the parents.

All of the hybrids are tetraploids with 2n=76 chromosomes. Abnormalities of pairing and chromosome distribution at meiosis were not especially frequent. The most typical first metaphase configurations were 32 to 34 II (bivalents), 1 to 3 I (univalents) and 1 to 3 III (trivalents) (Fig. 1.). Quadrivalents (IV) were occasionally observed. It would appear that there was considerable autosyndetic pairing among *M. grandiflora* chromosomes. If it is assumed that the 3 univalents and 3 of the chromosomes involved in trivalents are derived from *M. virginiana*, then there are possibly 13 interspecific

bivalents. Thus, at least 38 of the *M. grandiflora* chromosomes form intraspecific bivalents. Even though the observed irregularities of meiosis in the hybrids are not marked, there may be enough genetic segregation to result in a high proportion of non-functional gametes.

If we assume that *M. grandiflora* is a segmental allohexaploid, then its three 19-chromosome genomes would have some common segments. Pairing would be normal (bivalents), however, because of preferential pairing of sister chromosomes. When a segmental allohexaploid is back-crossed to one of its parental species, preferential pairing would lead to the nearly complete formation of bivalents. This type of behavior in the *M. virginiana* x *grandiflora* hybrids makes it likely that the ancestor of the present *M. virginiana* was also involved in the ancestry of *M. grandiflora.*

The high degree of bivalent formation does not, however, indicate that the plant will be fertile. Random segregation of chromosomes and crossing over will produce sterile gametes that are deficient for some chromosome segments and duplicated for others. This is apparently the case in the generally sterile *virginiana* x *grandiflora* hybrids.

Certainly the hybrids are not abundantly fertile. Both parent species are normally self-fertile but the hybrids rarely set seed to self or cross-pollination. Mr. William F. Kosar, at the National Arboretum, has raised several progenies from open-pollinated seed of the hybrids. These second-generation hybrids exhibit extreme morphological abnormalities in flower structure. The flowers, especially the tepals, are generally smaller than those of the F_1 hybrids, and the stamens are petaloid and produce no pollen. This condition also occurs in two of the first-generation hybrids. Thus the ornamental improvement potential of this cross is lost after the first generation. Nevertheless, McDaniel (1963), has used 'Freeman' in backcrossing to *M. virginiana*, but the progenies appear to be non-fertile.

M. liliflora x M. stellata

The eight hybrid cultivars of this cross were produced by Dr. Francis DeVos and Mr. William F. Kosar at the National Arboretum in 1955 and 1956. Dudley and Kosar (1968) have recently provided full descriptions of all the cultivars. The cultivars 'Ann', 'Betty', 'Judy', 'Randy', 'Ricki', and 'Susan', were all derived from a cross between *M. liliflora* 'Nigra' and *M. stellata* 'Rosea'. The female parent of 'Jane' and 'Pinkie' is given as *M.* x 'Reflorescens' while the males are *M. stellata* 'Rosea' and 'Waterlily', respectively. These hybrids represent crosses between members of different sections of the subgenus Pleurochasma, *M. liliflora* belonging to section Tulipastrum and *M. stellata* (Sieb. & Zucc.) Maxim. to the section Buergeria.

Cytological examination of the *M.* 'Reflorescens' (NA 2123) parent showed that it was a tetraploid with 2n=76 chromosomes. One chromosome did exhibit a precocious division and migration at first metaphase but there were no other irregularities of meiosis. Thus, it would appear reasonable to consider this cultivar as belonging to *M. liliflora.*

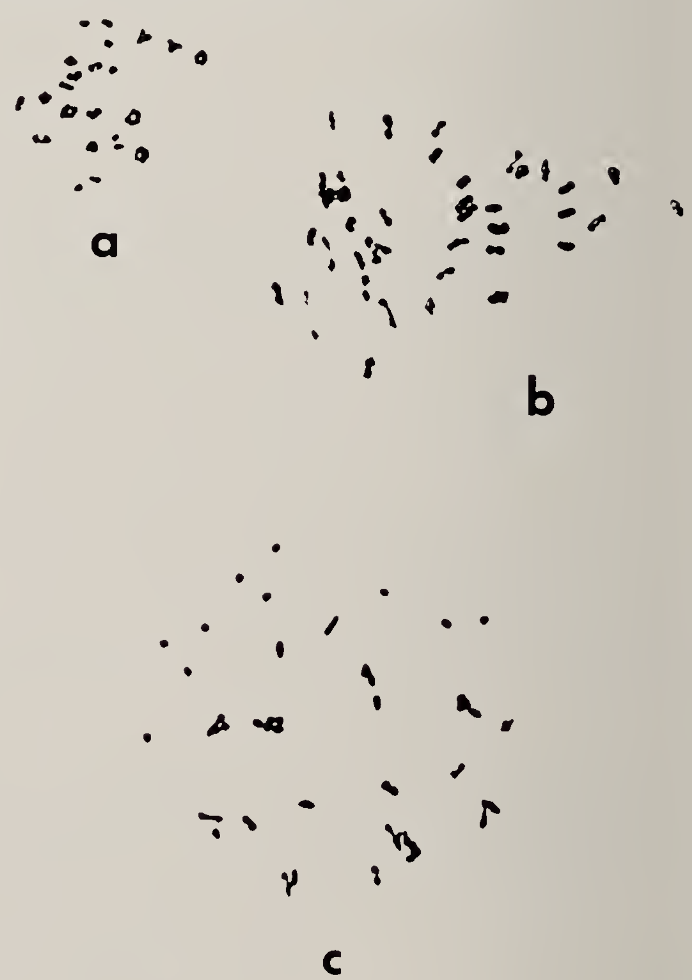

Fig. 1. Metaphase I in (a) *Magnolia virginiana* x *obovata*, 2n=38, showing 6 univalents; (b) *M. virginiana* x *grandiflora*, 2n=76; (c) *M. liliflora* x *stellata* 'Ricki', 2n=57. (530 X)

The plant of *M. liliflora* 'Nigra' (NA 2901) used as a female parent was also tetraploid with no meiotic irregularities. Both the 'Rosea' (NA 1415) and 'Waterlily' (NA 1413) cultivars of *M. stellata* were diploids with 2n=38 chromosomes. Pollen of the diploid male parents averaged 37.6 μ in overall diameter and was 95% fertile. The tetraploid female parents produced pollen that averaged 40.9 μ in diameter and was 92% fertile.

All of the hybrid cultivars were examined cytologically, and all were found to be triploids with 2n=57 chromosomes. The average pairing configurations at first metaphase were 12 I, 12 II, and 21 chromosomes involved in multivalents associations

(Fig. 1.). The high proportion of univalents indicates that there is little chromosome homology between the two parent species. It is likely that all of the *M. stellata* chromosomes are involved in univalent or multivalent formation; the 12 bivalents result from autosyndetic pairing of *M. liliflora* chromosomes.

Precocious migration of univalents was common in the triploids, and lagging was most prevalent at the first division. Chromosome counts at metaphase II ranged from 22 to 35 chromosomes, with most nuclei containing fewer than 28 chromosomes. Lagging and loss of chromosomes at the second division probably resulted in telophase II nuclei with even fewer chromosomes. While it is likely that the majority of the microspore nuclei contained more than 19 chromosomes, these may not have constituted a balanced set. Empty and distorted pollen grains accounted for 27% to 50% of the mature pollen, while grains with severe structural abnormalities made up from 34% to 58% of the total. The percentage of sound, probably viable pollen averaged only 16%. Pollen size varied from 30.4 μ to 50 μ, and undoubtedly contained some diploid grains and pollen of even higher ploidy.

The lack of fruit set and high sterility of these triploid hybrids can be accounted for by the cytological irregularities at meiosis.

M. VIRGINIANA x M. OBOVATA

This cross was made by Kosar at the National Arboretum in 1956. *M. obovata* Thunb. resembles *M. tripetala* in many ways and it is not surprising that the cytology of this diploid hybrid is similar to that of *M* x *thompsoniana* (Santamour, 1966). Up to six univalents were noted at first metaphase (Fig. 1.). The retention of "lost" univalents and the subsequent formation of dwarf microspores was less frequent than in *M.* x *thompsoniana*. Pollen abortion, based on empty and distorted grains was 94%. Thus, we must assume that gametes with fewer than 19 chromosomes are not viable; and the high sterility of this hybrid combination can be traced to irregularities of chromosome pairing at meiosis.

Literature Cited

Dudley, T. R. and W. F. Kosar. 1968. Eight new hybrid *Magnolia* cultivars. Morris Arb. Bull. 19: 26-29.

Ehrendorfer, F., F. Krendl, E. Habeler, and W. Sauer. 1968. Chromosome numbers and evolution in primitive angiosperms. Taxon 17: 337-353.

Freeman, Oliver M. 1937. A new hybrid *Magnolia*. Nat. Hort. Mag. 16: 161-162.

Janaki Ammal, E. K. 1953. The race history of magnolias. Indian Jour. Genet. Pl. Breed. 12: 82-92.

McDaniel, Joseph C. 1963. Recent hybridizations with American magnolias. Internat'l Pl. Propagators Soc. Proc. 13: 124-132.

Santamour, Frank S., Jr. 1966. Hybrid sterility in *Magnolia* x *Thompsoniana*. Morris Arb. Bull. 17: 29-30.

Whitaker, Thomas W. 1933. Chromosome number and relationship in the Magnoliales. Jour. Arn. Arb. 14: 376-385.

Book Review

"HANDBOOK ON MINIATURE GARDENS."
A. Sutcliffe, Guest Editor and M. J. Dietz,
Associate Editor. Brooklyn Botanic Garden.
1969. $1.25.

This fairly recent publication represents an addition to the highly successful and informative series of "Handbooks" which has been issued by the Brooklyn Botanic Garden. The current example which is based on a special printing of "Plants and Gardens" Volume 24, No. 3, includes some seventeen essays contributed by eight authors. A considerable range of attractive and interesting plant materials, including both woody and herbaceous species, is described at sufficient length to stimulate the enthusiastic gardener to explore further. Such procedure is facilitated by the helpful inclusion of a short list of selected references as well as a directory of nurseries from which plants and seeds may be obtained. Numerous, excellent illustrations are provided including a fascinating photograph of a newly introduced Patagonian species of *Oxalis*. It should intrigue the gardener who has experienced well-grown specimens of the related *Oxalis adenophylla*. This compact publication is available by mail from the Brooklyn Botanic Garden, 1000 Washington Avenue, Brooklyn, N.Y. 11225.

A. Orville Dahl

Report from the Langstroth Garden

Paul Haegele

A resident volunteer task force, numbering several hundred thousand workers, this summer utilized raw materials and facilities of the Morris Arboretum, under Staff management, in producing an exotic food substance which ultimately won top honors in a county-wide competition.

The unobtrusive labor pool began work in early spring, and continued its efforts until mid-July, averaging more than twelve hours each work day, seven days a week, excepting rainy weather. Their raw material sources were the flowering trees and shrubs which are the staples of the Arboretum, as well as the wild and introduced herbaceous plants which abound. Only very simple and inexpensive equipment was required from the Arboretum because the methods employed were basically very primitive, even though sophisticated and exacting chemical processes were involved.

The end-product of the group was a gourmet-style table food, composed of nearly pure carbohydrates, so refined as to be almost directly absorbable into the bloodstream with only the barest amount of digestive action or other bodily conversion. This product, judged in competition with others of its class, scored 93 points on a scale of 100, and was awarded a blue ribbon for excellence of quality.

The product was honey—United States Department of Agriculture Grade Fancy, Extra Light Amber—produced by the honeybees of the Langstroth Bee Garden from Arboretum flora, under the management of the Curator. Honey begins as the nectar secretion of blossoms (which is essentially an aqueous solution of sucrose) gathered by the honeybees, and is transformed by their industry and bodily processes into a mixture of glucose and fructose. Added attractions are minute amounts of minerals, vitamins, pollens, proteins, enzymes, other sugars, and essential oils.

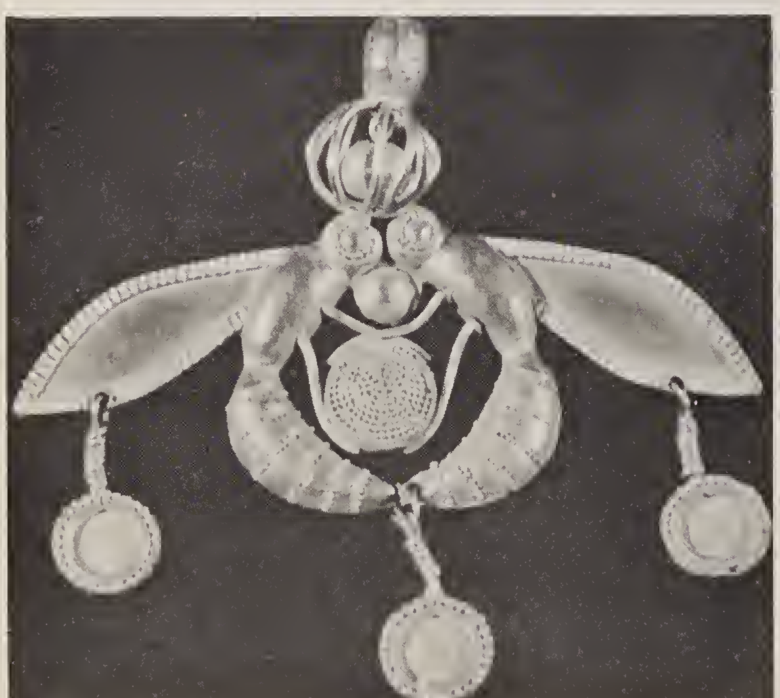

Fig. 1. Seventeenth-century, B.C. gold bee pendant from a tomb at Malea, Crete, now in the Herakleion Museum.

While this was not a bumper year for honey production, it was most gratifying where quality is concerned. Last winter was difficult, with four out of seven colonies in the Bee Garden succumbing to the rigors of the season. Fortunately, there was little swarming this spring, though this was a mixed blessing. Only one of our colonies swarmed, and these obligingly took up residence in a vacant hive in the Bee Garden, so their efforts were not entirely lost to us. On the other hand, the scarcity of swarms meant we were unable to pick up bees to replace our own winter losses.

The colony that swarmed, and the swarm itself, predictably produced no surplus honey this year, since their efforts were divided. Our two other colonies reached normal strength during the season, which is in the area of 75 to 100,000 bees per colony. These produced their average of about fifty pounds of honey per colony, and this was the lightest, most delicate I have seen from this area in ten years of beekeeping. It was judged first in its class for flavor, moisture content, clarity, and other qualities by Paul Ziegler, Chief Apiary Inspector of the Pennsylvania Department of Agriculture.

Why the honey this year was of such high quality, I cannot say, nor can I accurately identify its floral sources. I do know that we get a generous amount of privet honey here, and its characteristic faint anise-like flavor is present, but the bulk of the source could be white Dutch clover, wild mustard, or almost any combination of blossoms producing light-colored honeys.

In addition to the fifty pounds per colony surplus which the bees produce annually, the bees regularly produce sixty to ninety pounds per colony which they require for winter stores, as well as the amount they consume daily during the summer season. Add to this about three pounds of pure beeswax per colony annually, most of which is used in the cosmetic and pharmaceutical industries, and you must conclude that the honeybees' highly organized society is one which shows profits for its industry!

The Possible Role of Prenolepis imparis (Say) in the Dispersal of Mutinus caninus

Patricia Allison

The purpose of this note is to summarize important aspects of dispersal among the phalloid fungi, to report observations related to dispersal of *Mutinus caninus*, and to suggest ways by which new research might clarify the relationship of these fungi with other organisms and their environment.

The vivid coloration and strong odors of phalloid fungi, together with the multitude of observations of insects feeding on ripe gleba led to the inevitable, widespread centuries-old assumption that insects are their principal means of dispersal (16, 17) and that the basidiospore is the propagule dispersed. This assumption has never been satisfactorily confirmed.

Important Aspects of Dispersal

The relationship with insects begins with the eruption of the gleba-bearing receptacle from the confines of the egg (1, 5, 20). Prior to this, the egg is strikingly resistant to insect attack compared to fructifications of other members of the Gasteromycetes such as the puffballs (5, 11). The basis of this resistance is unknown. Nor is it known what triggers the sudden change in shape of the receptacle, yet it is precisely timed within the 24 hour day (5, 6) and can be exceedingly swift. Cobb (6) reported enlargement of *Ithyphallus coralloides* (*Phallus rubicundus*,Bosc. 27) to "several inches" in less than one minute. In consequence of receptacular elongation the odor from the maturing gleba is dispelled.

There is widespread disagreement regarding the acceptability to human nostril of the odor from a given species (3, 5, 7, 9, 11, 12, 25). It is reported (12) that Berkeley described a new species solely on the basis of a picture and the claim by someone else that the fungus smelled like violets (but see 11, p. 219). McIlvaine and McAdam list a Sowerby synonym for *Mutinus caninus*, namely, *Phallus inodorus*. The very early observations of Fulton provide a good basis for further developmental studies related to gleba deliquescence. He described three phases during which there were differences in viscosity, color, and odor as well. He further suggested that light mediated the process.

Until recently nothing was known about the chemical composition of the volatile fraction of the gleba of any phalloid fungus. Contemporary European workers have been studying *P. impudicus* (22, 23, 24, 29) and have reported the presence of hydrogen sulfide, methyl mercaptan, formaldehyde, acetaldehyde, phenylacetaldehyde, phenyl crotonaldehyde, and one or two amines (8).

Fig. 1. Freshly expanded receptacle of *Mutinus caninus*. It is so strongly curved that the tip bearing the moist gleba is touching the ground. The collapsed receptacle in the right foreground expanded the day before.

Little work has been done on the nonvolatile gleba fraction that would lead to a modern concept of its composition. The 1880 quote (12) from an uncited paper of Bracónnot, "it is composed of highly animalized fungin, albumin, mucus, superacetate of potash, and of a peculiar acid in combination with potash," is not highly informative. Another early report (in 11) lists "three forms of sugar, laevulose, dextrose, and gum." Present-day work with fruiting bodies of *P. impudicus* by European investigators in pharmacologically oriented institutions (19, 26) centers on blood-agglutinating proteins.

Whatever the composition of gleba, and however it changes during final maturation phases, a variety of organisms find it. Among the more numerous are flies and beetles, but cockroaches, earwigs, sowbugs, slugs, and ants have been observed also. There is no doubt whatsoever that flies eat the spores and go off with them, but what is their fate thereafter?

The early attempts of de Bary, Brefeld, and Ferguson to obtain germination of basidiospores of *P.*

Fig. 2. *Prenolepis imparis* workers cutting bits of *Mutinus caninus* receptacle.

impudicus failed (21). But Fulton (11) asserted that he had obtained basidiospore germination, having buried fly feces together with rabbit crotels or other "faecal matter" in glass tubes of "boiled" soil. He observed fluffy white mycelium two months thereafter, not spore germination. Basidiocarps did not form. The most often repeated claim of success is that of Cobb and his colleague Lewton-Brain who worked with *P. rubicundus* (21). Cobb thought he viewed "the beginning of germination" of a spore from fly feces and instructed Lewton-Brain to make a more thorough study. Hyphae were obtained from spore suspensions containing 0.001 M hydrochloric acid. Unfortunately, they and the cultures therefrom bore no resemblance to the distinctive mycelium of *P. rubicundus* in that there were no clamp connections and no typical crystals. Branching chains of conidia formed, yet imperfect forms of phalloid fungi are unknown. The claim must be set aside. Thus, if basidiospores can be effective propagules, it remains to be shown, Ingold (17) remarks, "there does not seem to be any subsidiary means of spread."

Mutinus caninus and Prenolepis imparis

For *M. caninus*, at least, there *is* evidence of a subsidiary means. Observations were made on an outdoor colony of *M. caninus* growing on wood chips and coarse sawdust. The glebal odor, as sometimes mentioned in the literature, was much milder than that of other phalloid fungi. As with woodland troops of basidiocarps, more often than not the receptacles were strongly curved and toppled over soon after elongation (Fig. 1).

Numerous workers of *Prenolepis imparis* crawled over the receptable (Fig. 2). Some of them lapped gleba; others moved about on the receptacle apex where they cut out fragments of fungus tissue approximately one millimeter square. These pieces were carried away from the fructifications and down into the wood chips (Fig. 3).

Doubtless many fungi are disseminated by ants in a purely coincidental fashion, as the pellet in their infrabuccal pouches is rarely devoid of fungal elements, but between this extreme and the extraordinary, obligate relationship of the leaf-cutting ants and their fungal gardens there are numerous others of diverse levels of adaptation (2). It thus becomes a question, not whether *M. caninus* is associated with *Prenolepis imparis*, but to what degree.

Adaptations favoring a somewhat specialized relationship include their sharing of habitat, glebal odor that is different from that of other phalloid fungi, the strong bending tendency of the receptacle, the feeding of the ant on the gleba, the transporting of fungal tissue, and, of course, the likely inclusion of spores and hyphae in the infrabuccal pouch pellet.

Cobb (6) was impressed with the activity of ants about receptacles of *P. rubicundus*. He mentioned their approaching in long files from down wind and their nesting habits in the sugar cane fields where the fungus was prevalent. Spores taken from ant digestive tracts appeared damaged, however.

Weber (28) seems to be the only one who has tried to evaluate a phalloid fungus-ant relationship experimentally. Because *P. impudicus* was found near the nests of *Acromyrmex octinospinosus*, he offered portions of the receptacle to a captive colony of the ant. Although the gleba was lapped up, the bits of receptacular tissue were hauled off to the colony refuse heap.

Research Needs

It is highly desirable to obtain axenic cultures that would form basidiocarps, yet many opportunities for field studies and for the investigation of material collected from the wild exist.

The process underlying rapid receptacle elongation is by no means peculiar to fungi of the Phallales. Whenever an ascus explodes, whenever a mushroom expands, the conversion of glycogen to simple sugars takes place. How? Modern investigations of *Sphaerobolus* (18), and other observations of development and pigmentation (1, 4, 11, 13, 14) lead us to suspect that light is critically involved. By virtue of their bulk and the fact that eggs separated from their mycelium will hatch, phalloid fungi could be valuable research material for the investigation of a ubiquitous, crucial phenomenon.

The volatile glebal constituents of additional species should be characterized. Different species of

fungi have different odors. Do they attract different animals? The resumption of behavioral studies (2) utilizing Dodson and Hill's (10) approach would be rewarding in that it couples gas chromatographic analysis of volatile materials with the bioassay of known mixtures on suspected dispersal organisms.

Because germination of basidiospores has not been observed probably means the investigative methods are ineffective rather than the spores. Attention should be given the fact that the compounds in the gleba of *P. impudicus* are not only highly reactive, but fungitoxic as well. Do they impose dormancy on the spore? Methods are known (15) for quenching the toxicity of similar materials. Or are there special external growth requirements similar to those now understood for some dung inhabiting fungi?

Simple histochemcial tests of the viability of spores in the egg, on the receptacle, in feces, and during laboratory treatment should prove informative.

The most pressing needs for the evaluation of the *Mutinus*-ant relationship could be met by additional field observations and the establishment of captive colonies of both fungus and ant.

Fig. 3. *Prenolepis imparis* worker carrying off a fragment of receptacle tissue. Part of the fallen receptacle can be seen in the background, left.

Literature Cited

1. Allison, Patricia. 1968. Ants, aphids, and stinkhorns. Morris Arboretum Bull. 19: 51-58.
2. Bailey, Irving W. 1920. Some relations between ants and fungi. Ecology 1: 174-189.
3. Bessey, Ernst Athearn. 1950-2. Morphology and taxonomy of fungi. Blakiston, Philadelphia. 792 pp.
4. Buller, A. H. R. 1922. Researches on fungi. Vol. II. Longmans, Green, London. 492 pp.
5. Burt, Edward A. 1897. Phalloideae of the United States III. On the physiology of elongation of the receptaculum. Botan. Gaz. XXIV: 73-92.
6. Cobb, N. A. 1906. Fungus maladies of the sugar cane. Hawaiian Sugar Planters' Assoc. Div. Path. and Phys. Bull. No. 5 (2nd ed.) 1-254.
7. ————. 1909. Fungus maladies of sugar cane. Hawaiian Sugar Planters' Assoc. Div. Path. and Phys. Bull. No. 6. 1-110.
8. Cochrane, Vincent W. 1958. Physiology of the fungi. John Wiley & Sons, Inc. New York, 524 pp.
9. Coker, W. C. and J. N. Couch. 1928. The Gastromycetes of the eastern United States and Canada. Univ. of N.C. Press, Chapel Hill, North Carolina. 201 pp.
10. Dodson, C. H. and H. G. Hill. 1966. Gas chromatography of orchid fragrances. Amer. Orch. Soc. Bull. 35: 720-725.
11. Fulton, T. Wemyss. 1889. The dispersion of the spores of fungi by the agency of insects, with special reference to the Phalloidei. Ann. Bot. 3: 207-238.
12. G[erard], W. R. 1880. Correlation between the odor of Phalloids and their relative frequency. Bull. Torr. Bot. Club. 7: 30.
13. Heim, Panca. 1946. Sur la localisation des pigments carotiniens chez les Phälloidées. Comptes. Rendus. 222: 1354-1355.
14. ————. 1946. Sur les pigments carotiniens des Champignons. Comptes. Rendus. 223: 1170-1172.
15. Horsfall, James G. 1956. Principles of fungicidal action. Chronica Botanica. Waltham, Mass. 279 pp.
16. Ingold, C. T. 1953, 1964. Dispersal in fungi. Clarendon Press, Oxford. 208 pp.
17. ————. 1965. Spore liberation. Clarendon Press, Oxford. 210 pp.
18. ————. 1969. Effect of blue and yellow light during the later developmental stages of Sphaerobolus. Amer. J. Bot. 56: 759-766.
19. Kalab, M. and Z. Matlocha. 1966. Electrophoretic separation of soluble mushroom proteins in acrylamide gel. Planta Med. 14: 126-130. Mycol. Absts. 1(3): 268.
20. Kinugawa, Kenjiro. 1965. On the growth of Dictyophora indusiata. II. Relations between the change in osmotic value of expressed sap and the conversion of glycogen to reducing sugar in tissues during receptaculum elongation. Bot. Mag. 78(923): 171-176. Abst. Mycol. 2(3): 133.
21. Lewton-Brain, L. 1906. Report on the germination of the spores of Ithyphallus. Appendix I. Hawaiian Sugar Planters' Assoc. Expt. Sta. Rept. Div. Path. and Phys. Bull. No. 5. 196-205.
22. List, P. H. and B. Fruend. 1966. Phenylcrotonaldehyd und andere Aldehyde als Geruchstoffe der Stinkmorchel, *Phallus impudicus* L. Naturwiss. 53: 585.
23. ————. 1967. 2-Phenyl-buten (2)-al(1), Reichstoff der Stinkmorchel. Naturwiss. 54: 368.
24. ————. 1967. Methylmercaptan und Schwefelwasserstoff, Geruchstoffe der Stinkmorchel (*Phallus impudicus* L.). Naturwiss. 54: 648.
25. McIlvaine, Charles and Robert K. McAdam. 1900. One thousand American fungi. Bowen, Merrill, Indianapolis. 704 pp.
26. Mustier, J. and M. Coulet. 1965. Localisation de l'hemagglutine de l'oeuf de Phallus impudicus L. ex Fr. Societe de Biologie de Clermont-Ferrand 23 juin, 1965. Mycol Absts. 2(6): 356. 1968.
27. Stevens, F. L. 1921. The fungi which cause plant disease. Macmillan, New York, 754 pp.
28. Weber, N. A. 1945. Biology of fungus-growing ants VIII. Acromyrmex octospinosus Reich. Rev. Entomol. (Rio de Jan.) 16: 1-88.
29. Wiegandt, Herbert. 1966. Phenylacetaldehyd als Geruchsstoff der Stinkmorchel. Naturwiss. 53: 200.

The Frost Mint

Donald Iffland

Is there a Frostman in your garden? There is if you have the common dittany, *Cunila origanoides* (L.) Britt. The unusual feature of this plant, also known as the Frost Mint, is that ribbons of ice develop around the stem on frosty mornings. The formations may resemble translucent fingers stretching out, or exquisite fluted vases, or smooth, curved works of sculpture.

Fig. 1. The Common Dittany, *Cunila origanoides*, becomes the Frost Mint on cold mornings when ribbons of ice form from liquid water leaving slits in the dead stems.

William Darlington, observing this phenomenon in *C. mariana* as long ago as 1837, wrote in *Flora Cestrica* that the ice forms may be produced "by the moisture from the earth rising in the dead stems by capillary attraction, and then being gradually forced out horizontally, through a slit, by the process of freezing." A modern evaluation of this view has not been found.

Frost Mint grows in acid soil in shaded rocky areas, or, according to Rickett, in dry open woods. It can be found from southern New York to Oklahoma and as far south as Florida. This wild flower also apparently does well in acid rock gardens; in fact the specimen pictured was growing in a rock garden in the suburban Philadelphia area.

The plant, about a foot tall, is a rather woody and wiry perennial that has a tendency to sprawl. In the late summer or autumn small purple flowers are produced in tufts at the tips of branches and in the axils of the leaves. It has been said that the thyme-scented leaves have not only been used for brewing tea but also for the treatment of snakebite and fever.

References

Darlington, William. Flora Cestrica. Third ed. Lindsay and Blakiston, Philadelphia. 1853. p. 199.

Rickett, Harold. Wild Flowers of the United States. McGraw-Hill, New York. 1966. p. 366.

Wherry, Edgar T. Wild Flower Guide. Doubleday, Garden City, N.Y. 1948. p. 112.

New Associates

The Arboretum is happy to welcome the following new Associates:

Mr. Thomas J. Delendick
Mr. William T. Fleming
Mrs. Jack Godfrey
Mrs. Andrew R. Klein
Mrs. Michael L. Logan
Mrs. Margaret McFadden
Mr. & Mrs. Wm. M. North
Dr. Raymond Weiner
Mrs. Robert J. Williams

Two New Species of Pseudocoprinus

Kent H. McKnight
and
Patricia Allison

Along the road that stumbles up the western slopes of the Andes toward Pilaló, Ecuador, can be seen a transitional zone of vegetation. Hidden below this 1850 meter level is the rich cloud forest; above, wide and windswept, the grassy páramo.

The mosaic of grassy and scrubby vegetation at this point is generally unattractive for mycological exploration, but an arroyo cut into the mountainside invited a search for certain small, transitory fungi. These are the Myxomycetes that present themselves in dampness and live out intervening times as spores or as crusty huddles of weatherproofed protoplasm.

After several weeks of the dry season, as in late July, 1963, the scrub and tufts of grasses on the upper slopes of the arroyo seemed lifeless, but there still was a little evidence of moisture among the lichens and the slender rim of withered mosses at the gully's edge. Here a few poor specimens of a common species of *Physarum* were found (Allison 1964) which were sufficient to convince one that other fungi might abound there at some other time of the year. Therefore, samples of potential slime mold substrates (leaves, twigs, mosses, and lichens) were put in containers separate from other collections. The hope was that these, placed in moist chambers 2,000 miles away, might yield a new crop in a laboratory-simulated wet season. They did—not a forest of tiny Myxomycetes—but the handsome, scientifically important little mushroom described below.

The second species described here comes from a much less exotic habitat. It grew on mossy soil under an oak tree in the lawn of the Forest Disease Laboratory of the U.S. Forest Service, Laurel, Maryland, and was found by Dr. O. K. Miller, Jr., and Mr. John Lindsay. We are grateful to them for the specimens, for the photograph reproduced here, and for Dr. Miller's notes taken on the fresh mushrooms which he generously made available to us. We are indebted also to Miss Edith Cash for writing the Latin descriptions. Color notations follow the Munsell (1966) system and the color names in bold-faced type are those of Kelly and Judd (1965).

Taxonomy

The genus *Pseudocoprinus* was established by Kühner (1928) for *Agaricus disseminatus* Pers. ex Fr., a species which has characters of both *Coprinus* and *Psathyrella* as these latter two genera are understood by contemporary mycologists. Singer (1949) recognized two species in the genus *Pseudocoprinus* Kühner: *P. disseminatus* (Pers. ex Fr.) Kühner, and *P. crenatus* (Lasch) Kühner ex Romagnesi. Smith and Hesler (1946), using a broader concept in the genus, published *P. besseyi* Smith and *P. lacteus* Smith in their report on dark-spored agarics from North America. Smith (1949) and Moser (1953) listed *P. impatiens* (Fr.) Kühner in addition to *P. disseminatus* and Smith (loc. cit.) claimed that the North American flora contained "a dozen to fifteen species" of *Pseudocoprinus*. A single species from the American tropics, *P. brasilianus* Batista was described more recently (1957). Later Singer (1962) followed Lange (1952), Kühner and Romagnesi (1953), and others in treating these species as members of *Coprinus* and abandoned *Pseudocoprinus*, at least temporarily.

The two new species reported here differ from all of those species listed above and from related species of *Coprinus* in a number of significant characters. One does not fit in any of the sections of *Coprinus* as defined by Singer (1962).

DESCRIPTION: **Pseudocoprinus venustus** McKnight & Allison, sp. nov. Figs. 1-6.

Pileus primum subglobosus deinde truncato-ellipticus tum convexo-expansus demun planus, disco interdum depresso et margine repando, 0.5-2.0 cm diam., plicato-striatus, ab initio aetatis radiatim lamellas adversum fissens; superficies furfuraceo-squamosa ad marginem fibrilloso-squamata atomata in juventate pallide aurantio-flavidula deinde grisea; odor et sapor indistinctus. Lamellae annexae, in aetate e pileo separantes et ad collarem annulumve affixae, maturae rugosae et in aspectu intervenosae, primum albae demum colubrinae maculosaeve. Stipes cartilagineus fragilis aequus ad basim bulbosus, 1-6 cm X 0.5-1.0 mm, albus nitens fibrillosus ad basim bulbo tomentoso flavidulo praeditus.

Squamae pilei pyramidatae, e cellulis globosis pyramidatis 10-45 μ diam. tenui-tunicatis squamae marginales e cellulis filamentosis, 20-45 x 2-5μ. Trama e cellulis irregulariter ex angulosis saccatis globosisve compositum. Cheilocystidia numerosa saccata usque clavata vel ventricosa, 25-60 x 13.5-20 μ;

Fig. 1. *Pseudocoprinus venustus* basidiocarps growing on oatmeal agar, X 2.25.

pleurocystidia sparsa, cheilocystidiis similia; paraphyses coprinoideae; sporae valde applanatae, in sectione transversali et in aspectu longitudinali uno anguste ellipsoideae, aliter visae nonnihil angulari-cordatae, 5.3-7.0 x 4.4-7.0 x 3.5-4.8μ; porus germinationis centralis prominens.

Hab. in culturis ad ramulos in Aequitoria lectos evolutis. Typus legit McKnight 10779 (BPI).

Pileus subglobose at first, later truncate-elliptic and finally expanding to broadly convex, eventually plane, sometimes with depressed disk and upturned margin; 0.5-2.0 cm in diameter; plicate-striate, splitting radially opposite lamellae at very early age; surface furfuraceous scaly, fibrillose scaly at margin, atomate, **pale orange yellow** (near 10YR 9/3) when young and on disk in old pilei, becoming gray elsewhere as trama splits from above and spores mature, flesh very thin, odor and taste not distinctive, margin straight and even at first, scalloped in fully expanded fruiting bodies, usually appendiculate from remnants of the annulus.

Lamellae adnexed, but in age separating from the stipe and still attached to a collar or ring, crowded at first but distant at maturity, splitting from above as pileus expands, sometimes for almost the entire width of the lamella, at maturity wrinkled and appearing intervenose, white at first but eventually mottled or speckled, edge sterile for 30-40 μ.

Stipe cartilaginous, fragile, even except for clavate bulb at base, 1-6 cm x 0.5-1.0 mm, surface white, shiny fibrillose, bulb tomentose, yellowish.

Pileus scales pyramidal, made up of globose and pyriform cells 10-45 μ in diameter, thin-walled, sometimes papillate, intermingled with occasional filamentous cells, marginal scales composed of filamentous cells, 20-45 x 2-5 μ, frequently constricted at cross walls, filaments parallel, seldom branching. Pileus trama of irregularly angular to saccate or globose cells, pale yellowish in H_2O and dull brownish in KOH. Cheilocystidia numerous, saccate to clavate or ventricose, 25-60 μ long x 13.5-20 μ wide at widest part, pleurocystidia sparse, similar to cheilocystidia. Paraphyses coprinoid, basidia 4-spored, dimorphic or trimorphic. Spores in mass **brownish black** (7.8YR 0.6/0.9), dark brown in water mounts, darkening in KOH, strongly flattened, narrowly ellipsoid in cross-section and in one longitudinal aspect, somewhat angular-cordate in outline in the other view; germ pore central, prominent; wall thick, smooth; 5.3-7.0 μ long, 4.4-7.0 x 3.5-4.8 μ wide.

HABIT, HABITAT & DISTRIBUTION: known only from specimens grown in culture. The first specimens developed in a moist chamber on twigs collected 29 VII 1963, at 1850 meters on the western slope of the Andes near Pilaló, Ecuador, by Patricia Allison.

COLLECTIONS STUDIED: McKnight 10779 (BPI) TYPE.

OBSERVATIONS: In its general appearance, its non-deliquescence, and its growth habit, this handsome little fungus bears a close resemblance to *Pseudocoprinus disseminatus* (Fr.) Kühner. *Pseudocoprinus venustus* may be distinguished readily, however, by its more ochraceous colors, persistent veil

Fig. 2. *Pseudocoprinus venustus*, same culture as in Fig. 1, earlier in the day, X 3.

remnants on the pileus margin, lack of cauloeystidia and piloeystidia, abundant cheiloeystidia, sterile gill edges, and shorter, distinctly flattened spores. The spores of *P. venustus* are smaller, cheiloeystidia are larger and pileus color is different from either *P. besseyi* Smith or *P. lacteus* Smith, whereas *P. brasilianus* Batista and *P. impatiens* (Fr.) Kühner have larger spores which are apparently not flattened, and larger cystidia. In addition, *P. impatiens* has cystidia on both stipe and pileus not found on *P. venustus*. Other characteristics of *P. venustus* which help to distinguish it from similar species in the closely related genera *Coprinus* and *Psathyrella* are the well-developed veil that leaves a distinct ring around the bulbous base of the stipe and the wrinkled gills which, at maturity, separate from the stipe but remain attached to a collar as in *C. plicatilis* (Curt. ex Fr.) Fr. and its var. *microsporus* Kühner & Joss. The spores are smaller than in either of these, however, and are shaped differently. The lack of a well-defined pileus cuticle and the ochraceous-tinted tramal cells of the pileus that are entirely converted to globose cells ultimately stacked in pyramidal scales are notable. The very early splitting of the pileus and gill trama and the extension of these clefts almost the full width of the gills are also of interest. The angular, flattened spores of *P. venustus* are much like those of *Coprinus angulatus* Pk. and *C. boudieri* Quél. but are smaller and differ in details of shape. The smaller germ pore, lack of piloeystidia and the habitat are also different from those recorded by both Josserand (1944) and Smith (1948) for *C. angulatus* and *C. boudieri*. The fungus is homothallic and fruits readily on oatmeal agar in 3 to 6 days from transfer of tissue or spores. Development of the fruiting bodies is hemiangiocarpic (bivelangiocarpic in the classification of Reijnders (1952). Longitudinal sections of very young primordia (Fig. 3) show a very thin layer of filamentous universal veil elements over the surface of the pileus. In slightly older primordia (Figs. 4, 5) these can be seen only near the margin of the pileus where they persist long after the outer layers of pileus trama at the apex of the pileus have been transformed into pyramidal scales of globose cells.

DESCRIPTION: **Pseudocoprinus brunneolus** McKnight sp. nov. Figs. 6, 7.

Pileus lato-convexus disco subdepresso praeditus, 10-17 mm diam.: discus glaber, modice brunneus, profundo plicato-striatus, e disco ad marginem roseogriseus usque brunneo-roseus; caro tenuis, odore et sapore carentibus.

Lamellae crassae, dissetae, cum lamellulis alternantes, primum albae deinde griseae demum sporis maturis fere atrae, margine acuto et superficiebus convergentibus praeditae, non deliquescentes, in maturitate e stipite separantes.

Stipes cartilagineus, fragilis, 20-50 x 0.5-1.0 mm. filiformis, semi-translucidus, albus, glaber, bizonatus,

Fig. 3. Young primordium of *Pseudocoprinus venustus* in longitudinal section, X 42.

Fig. 4. Old primordium of *Pseudocoprinus venustus* in longitudinal section, X 40.

Fig. 5. Old primordium of *Pseudocoprinus venustus*, X 30.

cellulis texturae centralis in zona interiori 4-5 μ, in zona corticali 1.3-3.5 μ diam.

Cuticula pilei e palo cellularum piroformium 25-40 x 15-18 μ composita; hypodermium in KOH ochraceum; cheilocystidia e subcylindrico clavata vel ventricosa, tenui-tunicata, fasciculata, 11-15 x 55-60 μ; pleurocystidia non visa; basidia tetraspora; basidiosporae in KOH sordide cacainae, a latere visae brevi-ellipticae et applanatae, a fronte angulato-ovoideae, distincte apiculatae, uniguttulatae, 9.0-11.8 x 6.7-7.0 x 7.9-9.7 μ, poro germinationis distincto lato apicali praeditae.

Hab. ad terram muscosam sub *Quercus*, Laurel, Maryland. Typus legit O. K. Miller 6919 (BFDL).

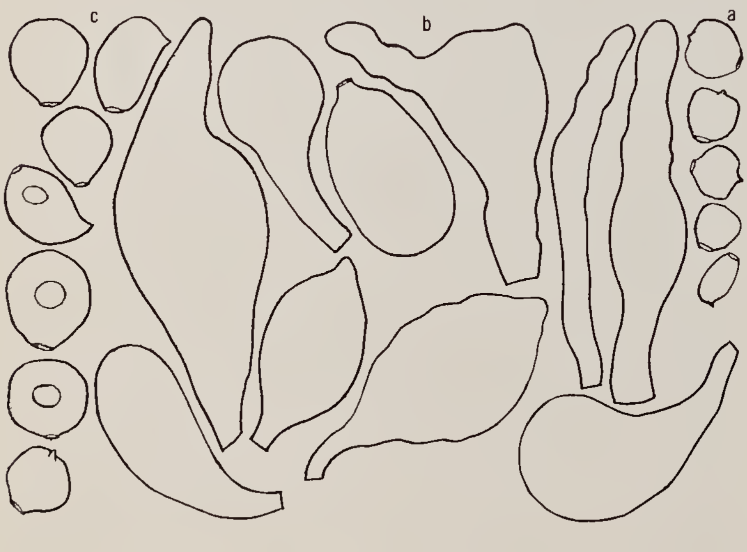

Fig. 6. Microscopic characters of two species of *Pseudocoprinus*, X 940. a. *P. venustus* spores; b. *P. venustus* cheilocystidia; c. *P. brunneolus* spores.

Pileus broadly convex with slightly depressed disk, 10-17 mm across; disk smooth, glabrous, **moderate brown** (7.5YR 2.9/3.4); deeply plicate-striate and **pinkish gray** (3YR 6.8/1.2) to **brownish pink** (6YR 6.7/2.1) from disk to margin; flesh thin, no odor or taste noted.

Lamellae thick, distant, alternating with lamellulae, white at first, becoming gray and then nearly black as the spores mature; margin acute and faces convergent, not deliquescent; at maturity separated from stipe.

Stipe cartilaginous, fragile, 20-50 x 0.5-1.0 mm, filiform, semi-transparent, dull white, glabrous, interior of two zones with cells of central tissue 4.5-14 μ in diameter and those of corticating zone 1.3-3.5 μ in diameter.

Pileus cuticle a palisade of pyriform cells 25-40 x 15-18 μ hypoderm ochraceous in KOH. Cheilocystidia subcylindric to clavate or ventricose, thin-walled, fascicled, 11-15 x 55-60 μ. Pleurocystidia not observed. Basidia 4-spored. Basidiospores dingy chocolate brown in KOH, short elliptical and flattened in side view, angular ovoid in face view, distinctly apiculate, uniguttulate, 9.0-11.8 long x 6.7-7.0 x 7.9-9.7 μ wide, germ pore distinct, broad, apical.

HABIT, HABITAT & DISTRIBUTION: Gregarious on mossy soil in lawn under *Quercus*, Laurel, Maryland. Known only from the type locality.

COLLECTIONS STUDIED: O. K. Miller 6919 (BFDL) TYPE, (BPI) ISOTYPE.

This species is close to *Pseudocoprinus lacteus* Smith, but differs in having darker colors, slightly larger spores of different proportions and in the lack of granular amorphous content in the cheilocystidia and cuticular cells of the pileus. Smith and Hesler (1946) emphasized the presence of this material as a distinctive characteristic of *P. lacteus*. Spores of *P. brunneolus* are similar to those of **Pseudocoprinus galericuliformis** (Watling) comb. nov.[1] and *Coprinus plicatilis* (Curt. ex Fr.) Fr., but are consistently smaller, more angular, and have an apical germ pore. In addition, *P. brunneolus* lacks the caulocystidia characteristic of *P. galericuliformis*. *Coprinus plicatilis* var. *microsporus* Kühner & Josserand has smaller spores than *P. brunneolus*. As illustrated by Kühner and Josserand (1934) the spores of *C. plicatilis* v. *microsporus* are also shaped differently, being less angular and narrower particularly toward the pore. The pruinose pileus surface which they described helps to distinguish them also as do their different cystidia. One of the most distinctive characteristics of

[1] basionym: *Coprinus galericuliformis* Watling. Watling, Roy. Notes on some British Agarics. Notes Roy. Botan. Gard. Edinburgh. 28: 39-56. 1967.

C. *plicatilis* is the wide collarium to which the lamellae are attached. This structure was not evident on the dried specimens of *P. brunneolus* and is apparently lacking, but its presence or absence should be verified on fresh specimens. **Pseudocoprinus subdisseminatus** (M. Lange) comb. nov.[2] is similar in appearance but differs in several microscopic characters including spore size and shape, cheilocystidia, and presence of pilocystidia.

The new species reported here are significant in three general areas of inquiry:

1. The discovery of additional species that fit well in *Pseudocoprinus* strengthens the case for retaining the genus in the broadened concept as a useful taxonomic entity.
2. The fact that *P. venustus* is homothallic and fruits readily in culture implies interest to students of "homothallic genetics" and of the evolution of heterothallism. That the basidia are four-spored instead of two-spored puts the fungus in an even smaller category for which little experimental material is available (Olive 1963, Raper 1963, Sequeira 1954, Smith 1934).
3. Finally, the rapid, profuse fructification of *P. venustus* on simple media assigns to it special value for studies of development and morphogenesis in higher fungi.

Fig. 7. *Pseudocoprinus brunneolus*, X 1.5

Literature Cited

Allison, Patricia. 1964. A Mycologist in Ecuador. Morris Arb. Bull. 15: 3-14.

Batista, C. 1957. Alguns Agaricaceae saprofitos de Pernambuco. Mycopath. Mycol. Applic. 8: 127-134.

Josserand, M. 1944.Études sur quelques Coprins. Description de deux espèces nouvelles. Bull. Soc. Mycol. Fr. 60: 5-18.

Kelly, K. L., & D. B. Judd. 1965. The ISCC-NBS method of designating colors and a dictionary of color names. Nat. Bur. Standards Circ. 553. U.S. Government Printing Office, Washington. 158 p.

Kühner, R. 1928. Le développement et la position taxonomique de l' *Agaricus disseminatus* Pers. Le Botaniste 20: 147-195.

_____, & M. Josserand. 1934. Description de quelques espèces du groupe de *Coprinus plicatilis* (Curt.) Fr. Bull. Soc. Mycol. Fr. 50: 53-63.

_____, & H. Romagnesi. 1953. Flore analytique des champignons supérieurs. Paris, Masson et Cie. 557 p.

Lange, M. 1952. Species concept in the genus *Coprinus*. Dansk Bot. Arkiv. 14: 1-164.

Moser, M. 1953. in Gams, H., Kleine Kryptogamenflora von Mitteleuropa. II. Blätter- und Bauchpilze. G. Fischer, Jena. 282 p.

Munsell, A. H. 1966. Munsell book of color. Munsell Color Co., Baltimore. 2 Vol.

Olive, Linday S. 1963. Genetics of homothallic fungi. Mycologia 55: 93-103.

Raper, John R. 1963. Patterns of Sexuality in Fungi. Mycologia 55: 79-92.

Reijnders, A. F. M. 1952. Recherches sur le developpement des carpophores dans les Argaricales. Kon. Ned. A. Wet., Verh. Afd. Nat. (Tweede Reeks). 48: 1-116, Pl. 1-25.

Sequeira, L. 1954. Nuclear phenomena in the basidia and basidiospores of *Omphalia flavida*. Mycologia 46: 470.

Singer, R. 1949. The Agaricales in modern taxonomy. Lilloa: 22: 1-832.

_____. 1962. ibid. 2nd ed. J. Cramer, Weinheim. 915 p., 73 Pl.

Smith, A. H. 1934. Investigations of two-spored forms in the genus *Mycena*. Mycologia 26: 305-331.

_____. 1948. Studies in dark-spored agarics. Mycologia 40: 669-707.

_____. 1949. Mushrooms in their natural habitats. Sawyer's Inc., Portland. 626 p.

_____, & L. R. Hesler. 1946. New and unusual dark-spored agarics from North America. Journ. Elisha Mitchell Sci. Soc. 62: 177-200.

[2] basionym: *Coprinus subdisseminatus* M. Lange. In Lange, M. & Smith, A. H. The Coprinus ephemerus group. Mycologia 45: 777 & 778. 1953.

Arboretum Activities

(Continued from Page 62)

attending the Twenty-Fourth American Horticultural Congress of the American Horticultural Society. In the afternoon, the Staff of the Arboretum were delighted to meet a group of Committee Chairmen and Directors of the Society. Formal papers relating to different areas of horticulture were presented during the period September 17-19 at the Society's headquarters, the Benjamin Franklin Hotel.

We were pleased to welcome a group of teachers, with Mr. Richard James as their guide, who, on October 8th, were in Philadelphia as participants in the annual meeting of the National Association of Biology Teachers.

On October 24th, we were delighted to meet with Mr. J. Eric Robson and Mr. William R. Hean, Gardens Advisers of the National Trust for Scotland.

The Barnes Lecture for 1969, a lecture series generously established in 1963 by a group of students and alumni of the School of Botany and Horticulture of the Barnes Foundation in honor of Dr. Laura L. Barnes, was held on November 12th. The distinguished lecturer for 1969 was Dr. Richard Evans Schultes, Director of the Botanical Museum, Harvard University. His superbly-presented, information-packed lecture on "Hallucinogenic Plants of the New World" was attended by almost 300 persons. Some of our readers may well find Dr. Schultes' essay on "Hallucinogens of plant origin", published in *Science* Vol. 163: 245-254, 1969, of much interest.

The Staff

Dr. Allison presented a lecture on "Fungal Spore Dispersal" on October 12th in the Academic Year Institute, supported by the National Science Foundation at the University of Pennsylvania. On October 21st, she described "Fungal Dispersal" for the Valley Garden Club in West Chester, Penn.

On September 3-6, *Dr. Li* participated, at the invitation of the National Science Foundation, in a seminar on "The Problems in the Distribution and Differentiation of the Plant groups Common to Japan and North America," held at the Oregon State University, Corvallis, Oregon. He presented a paper entitled "Eastern-Asia–Eastern-North America Species-pairs in wide-ranging genera."

In the widely-distributed Journal *BioScience* published by the American Institute of Biological Sciences, *Dr. Li* has just published (Vol. 19 : 882-883, 1969) a timely, thought-provoking article on "Urban Botany: Need for a New Science." At the XI International Botanical Congress held August 24 to September 2 in Seattle, Washington, The Morris Arboretum was represented by *Dr. Li* and *Dr. Dahl.* Approximately 4500 members from all over the world were in attendance at this congress which is held every five years. Each member of the Congress received an attractive volume published especially for the Congress under the title "A Short History of Botany in the United States" with Professor Joseph Ewan serving as Editor. The book includes an interesting "Calendar of Events" beginning with ca. 300 b.c. (e.g. "Storage baskets made of yucca leaves" by natives who lived in New Mexico) and ending with 1968 (e.g. "*Botanico-Periodicum-Huntianum* published by Hunt Botanical Library, listing 12,000 serials that contain plant science papers issued between 1646 and 1966".) Associates and friends of the Arboretum will find it of some interest that an entry for the year 1933 in this Calendar reads as follows "Morris Arboretum of 160 acres established at Chestnut Hill on the outskirts of Philadelphia as part of the University of Pennsylvania."

On November 3rd, Dr. Dahl provided a lecture on "Pollen and Palynology" for Dr. Henry Faul's course in Paleontology at the University of Pennsylvania.

A. Orville Dahl

International Ilex Registry Changed

The Holly Society of America and the International Registration Authority for cultivated *Ilex* (holly) wish to announce a change in the place of the registration authority *from* the College of Agriculture and Environmental Science, Rutgers, the State University, New Brunswick, New Jersey with Dr. E. R. Orton, Jr. as registrar *to* the U.S. National Arboretum, Washington, D.C., 20002, with Mr. Gene K. Eisenbeiss as registrar.

Book Reviews

THE BOOK OF SPICES. Frederic Rosengarten, Jr. Livingston Publishing Company, Wynnewood, Pennsylvania. 1969. $20.00.

The Book of Spices by Frederic Rosengarten, Jr. is an informative and useful book on a subject that is of interest to many people.

The book is divided into two parts. Part I, "What are Spices? A Brief History of Spices," provides a chronicle of the use of spices by ancient peoples as well as the search for Oriental spices by Europeans in the 15-16th centuries, with its initiation of the age of discovery. Also traced in this section is the subsequent struggle of powers in the Far East, down to the modern spice trade. Part II treats individually of over 40 kinds of spices, their botanical identity, cultivation, production, and utilization. A number of recipes follows each of the spices, amounting to over two hundred in all.

Thus the subject matter covers comprehensively areas that are of interest not only to growers and traders of spices but also to historians and ethnobotanists. It provides good reading for the general reader and furnishes helpful instructions for the housewife, the chef, and the gourmet. Although the author says modestly that it is a nontechnical book, the information contained therein is carefully researched and highly accurate. It is presented in a light style that provides delightful reading for every one.

The book is sumptuously illustrated by many color and black-and-white illustrations, meticulously assembled for the purpose. They are in most cases informative ones supplementary to the text. The many full-page color pictures of prepared food will undoubtedly further whet the appetite of the gourmet cook.

The author is to be congratulated for his effort in giving us a book of such high standard and long lasting value.

H. L. Li

A MANUAL OF PLANT NAMES. C. Chichcley Plowden. Philosophical Library, New York. 1969. $10.00.

The main contents of the book are an index of generic names with explanations of their origins or meanings, a vocabulary of specific epithets, an index of common names with botanical equivalents, and a glossary of botanical terms.

The basis of the selection of these names out of potential thousands of plant genera, is not clearly mentioned. As the work is intended for "gardeners, beginners or advanced, who want also to be plantsmen," presumably the names are mostly of cultivated plants, but this fact is not so indicated.

Thus the title of the book, *A Manual of Plant Names*, is deceptive. Not only will one look in vain for thousands of plant genera in the world flora, but he will find that many important cultivated plants, crops as well as ornamental shrubs and trees, are also absent. Genera like *Zea* (maize), *Hordeum* (barley), and *Avena* (oat) are listed, but *Triticum* (wheat), *Oryza* (rice), *Secale* (rye) are not. But these latter are listed in the list of common names.

The introductory chapter, "On the naming of plants, an introduction to the history of the naming of plants, and the rules which govern," consists of less than one and a half pages. All there is mentioned about rules is that "today the naming of plants follows the strict rules of the International Botanical Nomenclature." The terse treatment of the subject matter is found in other parts of the book, which include "the flower and the inflorescence," "the leaf," and one on "the plant system" which is mentioned by the author as adopted from Bailey's *Manual of Cultivated Plants.*

The author says that the information contained in his book would call for a considerable collection of reference books. Actually, nearly all the contents are readily available in Bailey's well known manual. The flyleaf says that "it is thought to be the only existing work of its kind." Vocabularies of botanical names and terms have appeared in numerous forms, from pamphlets to books or variously appended to manuals or floras. Among L. H. Bailey's many works there is *How Plants Get Their Names* (1933), which is comparable to the present volume in scope but incomparable as to its contents, for it is a beautifully written work, informative and instructive.

This work under review is one of very limited value.

H. L Li

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Morris
ARBORETUM BULLETIN

LEGES SINE MORIBUS VANAE

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Dr. J. R. Schramm, Professor Emeritus of Botany, Director Emeritus of the Morris Arboretum, University of Pennsylvania; Research Scholar, Indiana University. See page 15. Indiana University News Bureau photo.

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CLASSES OF MEMBERSHIP

Sustaining	$10.00 a year	Sponsoring	$100.00 a year
Supporting	$25.00 a year	Donor	$500.00

Arboretum Activities

All too few of the flower buds of our specimens of *Chimonanthus praecox* (L.) Link. (Wintersweet) survived our petulant winter. However, even the occasional, fragrant blossom of Wintersweet along with the more abundant flowers of *Acer saccharinum* L. (Soft, Silver or River Maple), *Eranthis hyemalis* Salisb. (Winter Aconite), *Leucojum vernum* L. (Spring Snowflake), *Galanthus nivalis* L. (Snowdrop), and *Crocus chrysanthus* Herb. (Snow Crocus) provide evidence of a more abundant vegetation relatively close at hand.

Attention to the essential improvements of grounds, buildings and equipment has continued. A third phase of major tree-pruning was completed in February. Such activity is necessarily part of a long-term plan. In instances where a specimen must be removed, a careful check is essential to make certain that a duplicate, replacement plant has been either propagated or planted elsewhere in the Arboretum.

(Continued on Page 20)

THIS ARTICLE IS BASED ON THE SEVENTH ANNUAL LECTURE HONORING DR. LAURA L. BARNES WHICH WAS PRESENTED ON NOVEMBER 12, 1969.

The New World Indians and Their Hallucinogenic Plants

RICHARD EVANS SCHULTES

"The passionate desire which . . . leads man to flee from the monotony of everyday life . . . has made him instinctively discover strange substances. He has done so, even where Nature has been most niggardly in producing them and where the products seem very far from possessing the properties which would enable him to satisfy this desire." (Lewin)

I.

One of the most fascinating aspects of ethnopharmacological research has centered on the study of man's use of hallucinogenic plants.

The utilization of hallucinogens—plants capable of inducing visual, auditory, tactile, taste, olfactory or other hallucinations—has always been connnected in primitive societies with religion or magic. Modern sophisticated western culture has now "discovered" hallucinogens and is employing them—sometimes with cultish zeal—far differently from the almost reverential way characteristic of man who lives closer to nature in primitive societies.

Even though aborigines employ direct palliatives or remedies to treat their ailments, the psychic effects of drugs are far more important to them than the purely physical. This outlook is understandable, since most primitive societies attribute sickness and death to supernatural forces. Witchcraft—communion with the spirit world—is the prime tool in treating disease. Consequently, aboriginal doctors value the unearthly effects of hallucinogenic plants that are able to take them beyond the prosaic confines of the worldly environment to exciting realms of indescribably ethereal wonder. What better way to diagnose disease and discover its cure than for the doctor to be transported for communion with the causative forces? Thus, the hallucinogens are his "medicines" *par excellence* and early won an unshakable place in magic and religious practices which, even though often indistinguishable, are the basis of his medical practices. And most, probably all, of the hallucinogens attracted great reverence, even rose to the rank of divinity, since man could explain these extraordinary properties only by assuming that a divine power dwelled within these most favoured of plants.

Of the many thousands of species of plants on the earth—variously estimated at from 250,000 to 800,000—only a few have been used as hallucinogens. Even a cursory survey of plant hallucinogens indicates how widely and unpredictably the known hallucinogenic plants occur in the Plant Kingdom, concentrated in the fungi and the angiosperms. It likewise hints at how tantalizingly rich in potentially psychoactive substances must be the plant world " . . . into whose silent growth and creative abundance man has not yet fully penetrated."

There must be many more species of plants with hallucinogenically active constituents than we now know. Even experimentally minded aborigines have not exhausted this field. But how many species has man used? The number seems to be fewer than one hundred. During the past half century, ethnobotanical investigation has uncovered a heartening array of such plants still employed in aboriginal societies, and there can be no doubt that an appreciable number undiscovered by modern science still lurk unheeded by the civilized world in its frantic rush. Fully half a dozen "new" hallucinogens have been discovered, even in the decade just passed.

Primitive societies of the New World utilize many more plants with vision-inducing properties than do those of the Old World—even though the floras of the two hemispheres would seem to be more or less comparably well supplied with species possessing psychoactive constituents. Fully sixty species are known to be employed hallucinogenically by Indians of the New World as compared with fewer than a dozen in primitive Old World societies.

There is an urgency for research into hallucinogenic plants amongst aboriginal peoples. Civilization is on an ever more accelerated march, penetrating most regions of the world still held by primitive societies. The consequent divorcement of aboriginal peoples from dependence upon their vegetal environment for the necessities and amenities of life has been set in motion; nothing will now check it. The resulting disintegration of knowledge of plants and their properties is frightening. Our challenge must be to salvage native botanical lore—especially that relating to folk medicine in its broadest sense—before it

Fig. 1. Flowering head of the peyote cactus (*Lophophora Williamsii*). Photograph by R. E. Schultes.

becomes forever entombed with the cultures that gave it birth.

A survey of the New World hallucinogens might be made from the botanical, chemical or geographical viewpoint. For the purposes of this short summary, the geographical viewpoint seems to offer the easiest way of accommodating all of the hallucinogens used in North, Central and South America. The following hallucinogens will be considered: sweet calomel, mescal bean, peyote; gí-i-wa; teonanacatl; ololiuqui, sinicuichi; yerba de la virgen; zacatechichi; toloache and other *Datura* species; ayahuasca, caapi, yajé; yakee, epená, nyakwana, paricá; yopo; vilca; huilca; yurema; rapé dos indios; cimora; San Pedro; keule; taglli; taique; tupa; latué; and several other psychoactive plants.

II.

Acorus: There is some evidence that the Indians of northern Canada chewed the root of *Acorus Calamus*—*flag root* or *sweet calomel*—for medicinal and stimulant purposes but that excessive doses of this aroid induced strong visual hallucinations. The hallucinogenic principle has been reported to be asarone and β-asarone.

Sophora: *Sophora secundiflora*, a leguminous shrub of the drier areas of the American Southwest and northern Mexico, yields the *mescal beans* formerly employed as an oracular and divinatory medium for visions in initiation rites in the ceremonial Red Bean Dance of the Plains Indians. Historical reports of mescal beans go back to 1539, but archaeological remains dating back earlier than 1000 A.D. suggest ritualistic use. Its utilization as an hallucinogen died out with the arrival in the United States of the much safer peyote cactus, since mescal beans, which contain the quinolizidine alkaloid, cytisine, can cause death by asphyxiation.

Lophophora: Peyote, or *Lophophora Williamsii*, one of the most ancient sacred hallucinogens of Mexico, is still in use in Mexico and the United States. This cactus is a small, grey-green, spineless, napiform plant containing up to 30 phenylethylamine and isoquinoline alkaloids, one of which—mescaline—induces visual hallucinations.

Peyote was first described by Hernández who, shortly after the Conquest of Mexico, studied the folk medicine of the Aztec and wrote about the strange properties of *Peyotl zacatecensis.* Many other early chroniclers detailed the strange effects of this cactus, saying that it "causes those devouring it to be able to foresee and predict things . . . or to discern who has stolen from them . . .; and other things of like nature . . . ." Peyote rites persist to the present time in northern Mexico, where the Tarahumares, Huichols and other Indians sacramentally eat the dried discoidal tops of the plant—the so-called "mescal buttons"—which have been ceremonially gathered. Known to the Indians of the United States at the time of the Civil War, peyote was adopted as a sacred plant, central element of a peyote cult indigenous to the Plains Indians, in the 1880's. The new religion spread fast and now, organized into the Native American Church, claims 250,000 believers in many tribes in the United States and Canada.

The mescal buttons are virtually indestructible and can be shipped long distances from the rather limited area of the plant's growth in central and northern Mexico and the Rio Grande Valley in Texas.

The visual hallucinations induced by the ingestion of peyote are so unearthly that they are responsible for the Indian beliefs in the supernatural, even divine, powers of this cactus; they have likewise greatly interested the modern scientist. Characterized by the most bizarre series of visions in indescribably rich colours, they continue in a kaleidoscopic motion for long periods of time, often synchronized with auditory, tactile and other hallucinations. The intoxication seldom has unpleasant after-effects and normal use of this narcotic, which is not addictive, is apparently not physically nor socially harmful. The

peyote religion of the American Indians teaches the highest moral concepts and has become an integral part of Indian life.

Peyote is considered by all Indians who use it a supernatural stimulant and medicine, as well as a sacrament, and is employed in cross-country running and hunting and in the treatment of a great variety of bodily ills.

Ariocarpus, Epithelanthus, Pachycereus: Sundry Mexican cactus genera are known to contain alkaloids which are potentially hallucinogenic but only several have been reported as actually employed by natives for their narcotic properties.

The Tarahumare Indians of northern Mexico use *Ariocarpus fissuratus*, called *sunamí* and *peyote cimarrón*, asserting that it is stronger than *Lophophora Williamsii.* Anhalonine has been isolated from an indeterminate species of *Ariocarpus.*

These same Indians likewise value *Epithelantha micromeris* as a narcotic. It is said "to make the eyes large and clear to see sorcerers, to prolong life and to give speed to runners." Chemical studies apparently have not yet been carried out on this cactus.

The gigantic *Pachycereus pectin-aboriginum*, called *cawé* by the Tarahumares, is employed as a narcotic, but whether or not it has truly hallucinogenic properties has not been established. Carnegine has been reported from this species, and an allied species, *P. marginatus*, contains pilocereine.

Ipomoea, Rivea: The Aztecs ingested for purposes of divination and in magico-religious ceremonies a small lentil-like seed which they called *ololiuqui.* It came from a vine with cordate leaves known as *coaxihuitl* or "snake plant."

Although the use of this narcotic persists to modern times, it has only recently been definitively identified as a member of the Morning Glory Family or Convolvulaceae: *Rivea corymbosa.* A second Mexican morning glory, *Ipomoea violacea*, has likewise recently been found utilized in the same way.

A number of references to ololiuqui and several illustrations in the early Spanish literature indicated that it was convolvulaceous. Hernández, who studied Aztec medicine between 1570 and 1575, wrote that " . . . it will not be wrong to refrain from telling where it grows, for it matters little that this plant be here described or that Spaniards be made acquainted with it." Another early record, dated 1629, reported that " . . . when it is drunk, this seed deprives of his senses him who has taken it, for it is very powerful." Still another referred to ololiuqui which " . . . deprives those who use it of their reason. The natives communicate . . . with the devil . . . when they become intoxicated with ololiuqui, and they are de-

Fig. 2. Capsules and seeds of *Rivea corymbosa*, the narcotic ololiuqui of the Aztecs. Drawn by G. W. Dillon.

ceived by the various hallucinations which they attribute to the deity which they say resides in the seeds . . . " And, in 1634, one chronicler reported the confession of an Indian who said, "I have believed in dreams, in magic herbs, in peyote, and in ololiuqui, in the owl, etc."

A more medically oriented document from early Mexico stated that for treating " . . . a serious fever, the medicine man advised the patient to take ololiuqui. The patient refused. Finally, however, the medicine man persuaded all members of the family . . . to drink ololiuqui to help the patient . . . All became drunk . . . and when they regained their senses, the sick man began to rage in agony, calling the doctor a knave and witch. With this, the patient died. It is not without concern that Christian priests see the facility with which the devil works amongst these people, even after they have been . . . accepted into the church."

Ololiuqui was used also as a magic potion. Aztec priests, before making sacrifices " . . . took a large quantity of poisonous insects . . . burned them . . . and beat their ashes together . . . with the foot of the *ocotl*, tobacco, ololiuqui and some live insects . . .

rubbed themselves with this diabolical mixture and . . . became fearless to every danger." One report actually ascribed analgesic properties to ololiuqui, saying that it was able " . . . to benumb the flesh, being applied in the manner of an emplaster . . . and for that it did appease and benumb the pain, they held it for an effect of health and a divine virtue."

Botanists first suggested that ololiuqui belonged to the Convolvulaceae in 1854, and later Mexican botanists reiterated this belief, even though no toxic principle was known in the morning glories.

In 1911, it was first suggested that ololiuqui was not convolvulaceous, but solanaceous. In 1915, an American ethnobotanist definitely identified ololiuqui as *Datura meteloides*—obviously an hallucinogen—but disregarded the very definite indications and illustrations in the early literature that a "vine-like" plant was involved. This "identification" gained wide acceptance, despite the opinion of several that a morning glory was the source plant. It was not until 1939 that botanical specimens employed as a divinatory hallucinogen were collected in Oaxaca and the utilization of a morning glory was authenticated.

Little interest in this discovery was evidenced until 1955, when psychologists found that seeds of *Rivea corymbosa* were, in reality, psychoactive. Early phytochemical studies on this plant, however, failed to disclose any biodynamic constituents. It was not until the discoverer of LSD—Hofmann—investigated *Rivea corymbosa* that lysergic acid derivatives were isolated from this species. Previously, these potent principles were known only from the ergot fungus, *Claviceps purpurea*. Their discovery in one of the most advanced families of the higher plants was, to say the least, surprising.

Now these organic constituents are known not only from *Rivea corymbosa* but also from *Ipomoea violacea*, the other convolvulaceous species employed in Oaxaca as an hallucinogen. The lysergic acid derivatives responsible for the psychotomimetic activity of these morning glories are: ergine and isoergine. Chanoclavine, elymoclavine and lysergol, all present in the seeds of *Rivea corymbosa*, seem not to be involved in the intoxication produced by the plant itself. Seeds of *Ipomoea violacea* lack lysergol but have another compound, ergometrine, which is absent in *Rivea* seeds.

The seeds of *Ipomoea violacea* have been identified as the *tlitliltzin* of the ancient Aztecs: this term is a Nahuatl word for "black," with a reverential suffix added. The seeds of *Ipomoea violacea* differ from those of *Rivea corymbosa* in another respect, in being jet black. An old chronicler wrote of "*ololiuqui, peyote* and *tlitliltzin*," ascribing to all three the same properties.

Recent phytochemical studies have indicated that sundry species of the Convolvulaceae contain these indole derivatives. Various species of *Argyreia, Convolvulus, Ipomoea* and *Stictocardia* have been reported as containing these bases; and a number of horticultural derivatives of *Ipomoea violacea* are known to contain them in sufficient concentration to intoxicate, a fact which certain fringe groups in European and American society were not long in discovering and in utilizing. The abuse of the hallucinogenic employment of convolvulaceous seeds became so serious at one time that law enforcement agencies in Europe and the United States were forced to take steps towards controlling their non-horticultural use.

Cytisus: Yaqui medicine-men in northern Mexico employ *Cytisus canariensis*, a leguminous shrub native to the Canary Islands and introduced into Mexico. Known also as *Genista canariensis*, this plant is rich in cytisine, a highly toxic quinolizidine alkaloid commonly found in the Leguminosae.

Calea: One of the most recently discovered hallucinogens involves *Calea Zacatechichi*, a popular Mexican folk-medicine, an inconspicuous composite shrub ranging from central Mexico to Costa Rica.

Although there seems to be no magico-religious cult connected with this plant, the Chontal Indians of Oaxaca, believing in the visions they see in dreams, take a tea and smoke cigarettes of the dried leaves of *Calea Zacatechichi* whilst lying down quietly. It is valued as "a clarifier of the senses" by the Chontal medicine-men who call the leaf *thle-pela-kano* or "leaf of god."

Preliminary chemical examination has disclosed the presence of an alkaloid, still uncharacterized, in this shrub.

Salvia, Coleus: It is surprising to find members of the Mint Family utilized as hallucinogens in Mexico.

In Oaxaca, the Mazatec value the crushed leaves of *Salvia divinorum*, known as *hierba de la Virgen* or *hierba de la Pastora*, in divinatory rites when other more potent hallucinogens are not available. It has been suggested that *Salvia divinorum* may represent the *pipiltzintzintli* of the ancient Aztecs.

A toxic constituent has still not been found in this mint, even though investigators have experimentally substantiated its psychotomimetic effects.

The leaves of two other labiates—*Coleus pumila* and *C. Blumei*, both native to southeast Asia—are similarly employed by the Mazatec Indians of Oaxaca for inducing visions. Chemical studies of these two species, at least on the basis of Mexican material of

reputed hallucinogenic properties, have not been carried out, and no psychoactive principle is known from the genus.

Heimia: An interesting and still poorly understood Mexican hallucinogen is the lythraceous *Heimia salicifolia*, known by its Aztec name *sinicuichi.* This narcotic is an interesting auditory hallucinogen, but it does not induce visual hallucinations.

The leaves, slightly wilted, are crushed in water, and the juice is set in the sun to ferment. The resulting drink is mildly intoxicating, causing giddiness, drowsy euphoria, a darkening of the surroundings, a shrinking of the world around, altered time and space perception, forgetfulness, auditory hallucinations and removal from a state of reality. Sounds seem to come distorted from a great distance. The natives hold sinicuichi to be sacred, endowed with supernatural powers: that it helps them recall vividly events of many years earlier, that it permits them even to remember prenatal events.

Five quinolizidine alkaloids have been found in *Heimia salicifolia.* The major psychoactive alkaloid appears to be cryogenine, which has been shown experimentally to "mimic qualitatively and semi-qualitatively the action of the total alkaloid extract" of the plant.

Rhynchosia: A number of species of the leguminous genus *Rhynchosia*—especially *R. phaseoloides* and *R. pyramidalis*—are called *piule* in southern Mexico, a kind of generic term signifying narcotics and sometimes applied to the hallucinogenic morning glory seeds. The red-and-black beans of *Rhynchosia* are equated together with hallucinogenic mushrooms on the slopes of Mt. Popocatepetl and are said sometimes to be ingested with the fungi.

There is vague evidence that, in southern Mexico, *Rhynchosia* seeds may be employed as a divinatory narcotic. The Indians recognize them as toxic. Although there seem to be no definite indications in the literature of their narcotic use in pre-Conquest times, they may be represented, together with mushrooms, falling from the hand of the Aztec god of rain, in the Tepantitla fresco dating from 300-400 A.D.

The chemistry of *Rhynchosia* seeds is not well known. An unidentified alkaloid has been reported in *Rhynchosia pyramidalis.*

Erythrina: In some parts of Mexico, seeds of several species of the leguminous *Erythrina* may have been used locally as hallucinogens. They resemble those of *Sophora secundiflora*, are sometimes sold in native market places mixed together; and they are both called *colorines.* The seeds of several species of *Erythrina* contain toxic indole or isoquinoline derivatives.

Lycoperdon: The Mixtecs of Oaxaca employ several puffballs as hallucinogens. One species, *Lycoperdon marginatum*, characterized by a strong odour of excrement, is known in Mixtec as *gí-i-sawa* or "fungus of secondary quality." The other and more active species, *Lycoperdon mixtecorum*, is called *gí-i-wa* or "fungus of first quality." They do not appear to be so important as the hallucinogenic mushrooms are amongst the neighbouring Mazatec.

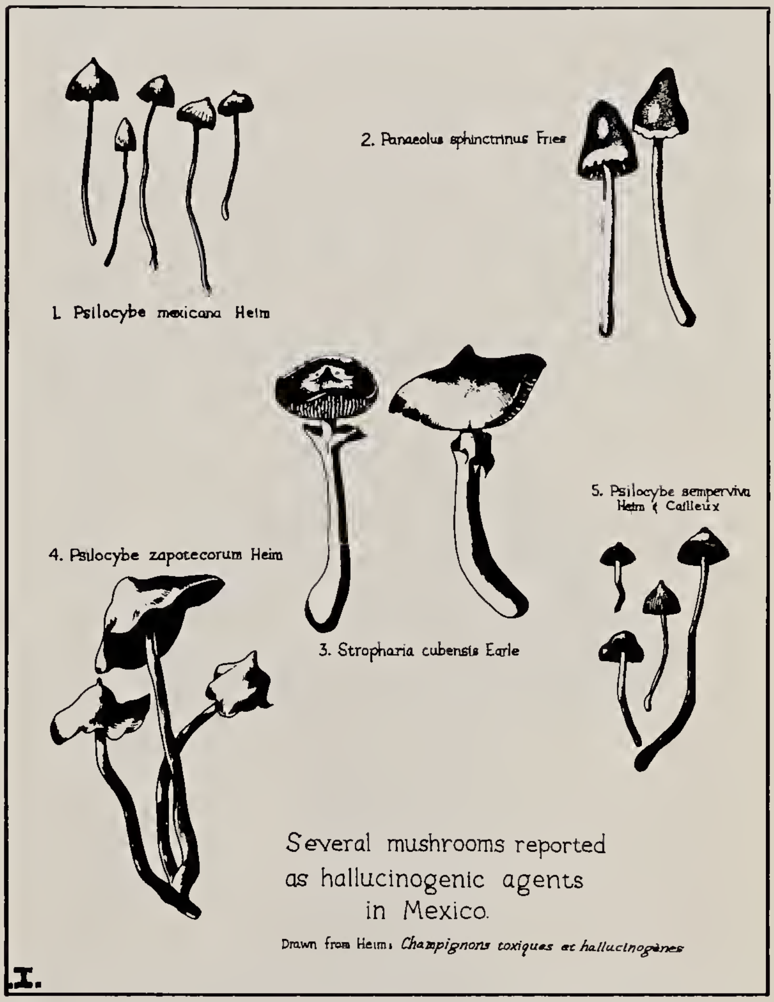

Fig. 3. Hallucinogenic mushrooms of Mexico. Drawn by I. Brady.

After ingestion of one or two specimens, one experiences a state of half-sleep and hears voices and echoes. The voices respond to questions posed to them. These puffballs may not produce visual hallucinations, but they definitely are auditory hallucinogens, if the reports of the natives are to be accepted. As yet, there is no chemical basis on which an evaluation of the reported effects of these fungi can be made; no psychoactive constituent has been reported from the puffballs.

Conocybe, Panaeolus, Psilocybe, Stropharia: The conquerors of Mexico found the Aztecs and other Indians using hallucinogenic mushrooms in religious and divinatory rites and in witchcraft. The sacred mushrooms—known by the Aztecs as *teonanacatl* ("flesh of the gods")—permitted them to commune with the spirit world.

The early Spanish chroniclers made many references to these "diabolic mushrooms" and described their effects and the rites surrounding their employment in great detail. European persecution drove the cult into hiding in the hinterlands, and no evidence that the narcotic use of mushrooms had persisted was uncovered until about 30 years ago. Modern botanists even postulated that teonanacatl was peyote: that, since the dried crown of the cactus resembled a dried mushroom, early writers had confused the two or had been deliberately duped by the Aztecs.

Finally, in the late 1930's, several investigators found an active mushroom cult amongst the Mazatecs in Oaxaca and collected *Panaeolus sphinctrinus* and *Stropharia cubensis* as the active mushrooms. Later work has established that more than two dozen species in at least four genera are hallucinogenically employed in six or more Mexican tribes. Furthermore, it now appears that mushroom worship is very ancient and was once spread over a much wider area. Archaeological "mushroom stones," excavated in great numbers from highland Mayan sites in Guatemala, are dated at 1000 B.C. They consist of a stipe with a human or animal face crowned with an umbrella-like top. They indicate the probability of a sophisticated mushroom cult at least 3000 years ago.

Fig. 4. Mushroom stone of the last pre-classic Maya period, 500 B.C. to 200 A.D.

While there are many species known to be employed—and many more known to possess the hallucinogenic constituents but apparently not used—the most important in Oaxacan mushroom rites are apparently *Psilocybe aztecorum*, *P. caerulescens*, *P. mexicana*, *P. zapotecorum* and *Stropharia cubensis.* All contain an extraordinarily psychoactive indolic compound with a phosphorylated hydroxyl group—psilocybine—and sometimes also the unstable derivative psilocine. Psilocybine is the only natural indole with a phosphoric acid radical known from the Plant Kingdom. It has been isolated from various species of *Conocybe*, *Panaeolus*, *Psilocybe* and *Stropharia* and appears to be restricted to the mushrooms.

It is interesting to note that early Jesuit missionaries in the Peruvian Amazon reported that the Yurimagua Indians prepared an intoxicating beverage from a "tree fungus." *Psilocybe yungensis* has been suggested as a possible identification of this mushroom, but no evidence points to its use in the region at the present time.

Datura: One of the most ancient narcotics in both the Old and New Worlds is *Datura.* Several species of this solanaceous genus—especially *D. inoxia (D. meteloides)* and *D. Stramonium*—have been valued as hallucinogens in religious, divinatory, curative and other magic rites in Mexico and other parts of North America.

In the dry American Southwest, many tribes have utilized *Datura inoxia* ceremonially, with a noticeable concentration in California, Arizona and New Mexico. The Zuñis, for example, employ it extensively not only as a narcotic but also as an anaesthetic and in the treatment of wounds and bruises. The rain-priests put the powdered root into the eyes when they commune with the spirits of the dead who intercede for rain. The Zuñis hold that this plant had a divine origin. In Mexico, this and other species of *Datura* are called *toloache* and still retain their ancient ritualistic uses for divination, prophecy and in treating disease.

Even in the American Northeast, the Algonquins and other tribes employed what is thought to have been *Datura Stramonium*—the jimson weed—as the chief ingredient in an inebriating medicine called *wysocean* that was given to youths undergoing

initiation rites. The adolescents " . . . become stark, staring mad, in which raving condition they are kept eighteen to twenty days. Thus, they unlive their former lives and commence men by forgetting that they have ever been boys."

All of the South American representatives of *Datura* are arborescent and belong to the subgenus *Brugmansia*, sometimes treated as a distinct genus. They are all native to the Andean highlands—*D. arborea*, *D. aurea*, *D. candida*, *D. dolichocarpa*, *D. sanguinea*, *D. vulcanicola*—or to the warmer lowlands—*D. suaveolens*. They are handsome trees, well known in horticulture, but they appear to be chromosomally aberrant cultigens unknown as wild plants. Their classification has long been and still remains uncertain: usually considered to represent six or seven species, the tree Daturas have recently been thought to comprise three or four species and a number of cultivars.

In South America, the preparation and use of *Datura* differ widely. It is most frequently taken in the form of pulverized seeds, sometimes dropped into beverages. The intoxication, fraught with grave dangers because of the extreme toxicity of the alkaloids, is marked by an initial state of violence so furious that the partaker must be restrained until a deep, disturbed sleep overtakes him. The visual hallucinations are interpreted as spirit visitations.

Amongst the Ecuadorian Jívaro, for example, *Datura* is employed to correct refractory children in the belief that ancestral spirits carry out the admonishing. The Chibcha of Colombia anciently gave women and slaves potions of *D. aurea* to induce stupor prior to their being buried alive with departed husbands or masters. The Inca are also known to have valued *Datura* as an intoxicant. It is still important in many areas from Colombia to Chile, along the Pacific Coast of northern South America and in certain parts of the Amazon. The Kamsá and Ingano tribes of Sibundoy in the southern Colombian highlands use *Datura* extensively: they even preserve for use and propagate vegetatively highly atrophied, named clones of several species. There is even a report of witch-doctors of the Ecuadorian highlands taking lessons recently from Jívaro medicine-men to reintroduce its use into the populous and now civilized Andean tribes.

Accurate identification of the species used by the tribes for special purposes leaves much to be desired, but since most species are known to contain similar tropane alkaloids—hyoscyamine, nor-hyoscyamine and scopolamine, varying usually but in relative concentrations—this problem is not so serious as in the case of certain other narcotics.

Fig. 5. *Datura sanguinea* in flower and fruit. Bogotá, Colombia. Photograph by R. E. Schultes.

What may represent possibly an extreme variant of an indeterminate species of tree-Datura has been described as a distinct genus: *Methysticodendron Amesianum*. Native to the high, mountain-girt Sibundoy Valley in southern Colombia, where it is one of the most valued hallucinogens of the Kamsá and Ingano, this plant appears to be a strict endemic known only in cultivation. Like the tree-Daturas, it contains the tropane alkaloids—with up to 80% of the total alkaloid content comprising scopolamine.

Brunfelsia: Evidence for the narcotic use of the solanaceous genus *Brunfelsia* is quite real but not yet corroborated by a good body of evidence and field observation. Several species may have been employed in the Amazon as hallucinogens, and one species is known to be added to the narcotic *Banisteriopsis* drink by the Jívaro in Ecuador. *Brunfelsia Tastevini* is reputedly utilized by the Kachinaua Indians of the Brazilian Amazon to prepare an hallucinogenic drink, but this report needs confirmation. Several vernacular names likewise seem to indicate former use of *Brunfelsia* as an intoxicant.

We know that chemical constituents in *Brunfelsia* are psychoactive, so there is no reason why these plants could not have been employed as vision-inducing intoxicants.

Latua: A century ago, a spiny shrub or small tree of Chile, now called *Latua pubiflora*, the only member of an endemic solanaceous genus, was identified as a virulent poison inducing delirium and visual hallucinations. It was employed by local Indian witch-doctors, who knew the shrub as *latué* or *árbol*

Fig. 6. *Datura vulcanicola* in flower. Volcán de Puraeé, Departamento del Cauea, Colombia. Photograph by R. E. Sehultes.

de los brujos, to eause permanent insanity.

Phytochemieal studies indieate the possible presenee of tropane alkaloids.

Banisteriopsis: In 1851, the British plant explorer Spruee diseovered a bizarre hallueinogen in use amongst the Tukano of the upper Rio Negro basin in Brazil. Known as *caapi*, the drug was taken in magieo-religious rites. Spruee identified it as a new malpighiaeeous speeies, now known botanieally as *Banisteriopsis Caapi*. Several years later he eneountered the hallueinogen *ayahuasca* in Eeuador and surmised correetly that it was from the same plant. At about the same time, in 1858, Villavieeneio, in his *Geografía del Ecuador*, wrote that the Zaparo, Angatero, Mazan and other tribes of Amazonian Eeuador took the drug to foresee the future, diseover the truth, help deliberate war, attaek and defense, learn the souree of hexing, weleome foreign visitors, aseertain the love of their women.

Probably no hallueinogenie preparation has been so fraught with eonfusion, primarily beeause of eareless researeh or even guesswork. Known by a number of loeal native names, the intoxieating drink prepared from *Banisteriopsis Caapi*, or the now more reeently deseribed *B. inebrians*, is ealled *ayahuasca*, *caapi*, *yajé*, *natém pinde* or other epithets. It is employed in the western half of the Amazon basin, espeeially near the foothills of the Andes, and by natives living in the rain-forests on the western slopes and Pacific eoast of Colombia and Eeuador. In some areas, a eold water infusion is prepared from the bark; in other loealities, the bark is subjeeted to long boiling in manufaeturing the drink. While *Banisteriopsis Caapi* is normally employed as a drink, it may also be used as a snuff. Harmala alkaloids typieal of this speeies have been reported from a snuff prepared from "a vine" said to be also the souree of an intoxieating drink.

It has been proposed that the apoeynaceous *Prestonia amazonica (Haemadictyon amazonicum)* was the souree of yajé, whilst ayahuasca and eaapi were derived from malpighiaeeous speeies. This idea, widely established in ethnologieal and ehemieal literature, has been shown to be erroneous by reeent studies.

To this day, the natives of the northwest Amazon use *Banisteriopsis* for prophetie, divinatory and magie purposes and to fortify the bravery of male adoleseents about to undergo the painful *yuruparí* eeremony of initiation. The nareosis may be violent and with unpleasant after-effeets, but these effeets may be due to eertain admixtures or to the boiling of the bark of the *Banisteriopsis* liana. Usually the intoxieation—espeeially when a eold water infusion of the bark is taken with no admixtures—has no unpleasant after-effeets; the intoxieation itself is charaeterized by a pleasant euphoria, followed by visual hallueinations in eolour but initially very often more or less tinged with blue or purple. In exeessive doses, it brings on frighteningly nightmarish visions and a feeling of extremely reekless abandon, although eonseiousness is not lost nor is the use of the limbs unduly affeeted.

The bark of *Banisteriopsis Caapi* and *B. inebrians* have β-earboline alkaloids sueh as harmine, harmaline, d-tetrahydroharmine as the active eonstituents.

A variety of plant materials are oeeasionally added to the drink prepared basieally from bark of *Banisteriopsis Caapi* or *B. inebrians*. These inelude plants definitely known to be toxie or nareotie, sueh as *Datura suaveolens* or speeies of *Brunfelsia*. Tobaeeo is said also to be employed as an admixture. The Tukanos of the Río Vaupés utilize five or six "vines," as yet botanieally unidentified, as additives. Perhaps the most interesting are the leaves of another speeies of *Banisteriopsis*, *B. Rusbyana* and of *Psychotria viridis*, added to heighten and lengthen the hallueinations. Analysis of leaf material of these two additives has indieated the presenee of the highly hallueinogenie N,N-dimethyltryptamine, thus substantiating the natives' assertion that the addition of these leaves increases the psyehotomimetie aetivity of the nareotie drink.

Tetrapteris: The Makú Indians in the northwesternmost sector of the Brazilian Amazon prepare an hallucinogenic drink from the malpighiaceous vine *Tetrapteris methystica.* A cold water infusion of the bark with nothing added has a yellowish hue and induces an intoxication characterized by visual hallucinations very similar to that of the *Banisteriopsis* preparations.

The Indians of this area called the drink *caapi*, the name applied also to the *Banisteriopsis* drink. Several earlier writers mentioned more than one "kind" of caapi in the region. This *Tetrapteris* preparation may represent the *caapipinima* ("painted caapi") reported from the Rio Uaupés of Brazil.

No chemical studies have been made of this species, but it is probable that the active constituents are the same or similar to those of the related species of *Banisteriopsis.*

Anadenanthera: In the Orinoco Valley of Colombia and Venezuela and adjacent parts of Brazil, a snuff called *yopo* or *ñopo* is prepared from the beans of the leguminous tree *Anadenanthera peregrina.* This species has also been called *Piptadenia peregrina.* Von Humboldt, Spruce and other explorers encountered the snuff and were impressed with its hallucinogenic potency.

This same snuff represents probably the ancient *cohoba* encountered in use in Hispaniola by Columbus' second voyage in 1496 but now apparently no longer employed in the West Indies due to the near-extinction of aborigines in these islands.

The beans of the tree—an inhabitant normally of open savannah-like areas—are roasted, crushed and mixed with ashes or calcined shells, but there is some variation in preparation from tribe to tribe. The powder is blown into the nostrils through bamboo tubes or snuffed individually through bird-bone tubes. The intoxication is often characterized by fury, followed by an hallucinogenic trance and an eventual stupor.

Five indoles have been isolated from these beans, including N,N-dimethyltryptamine and the related bufotenine.

Indirect evidence suggests that another species, *Anadenanthera colubrina,* may once have been valued as the source of narcotic snuffs known as *vilca* or *huilca* in southern Peru and Bolivia, and known as *cébil* in northern Argentina. Closely related botanically to *Anadenanthera peregrina*, this species has a very similar chemical composition and may well have been the source of these southern hallucinogenic snuffs.

Mimosa: An infusion of the roots of the leguminous *Mimosa hostilis* and possibly other species forms the centre of the ancient Yurema Cult of the Karirí, Pankararú and other Indians of the State of Pernambuco in eastern Brazil. This "miraculous drink," said to induce glorious visions of the spirit world, was taken by priests, warriors and strong young men and enabled them to "catch a glimpse of the clashing rocks that destroy souls of the dead journeying to their goal or to see the Thunderbird shooting lightning from a huge tuft on his head and producing claps of thunder by running about." An early report of yurema dates from 1788, and another, from 1843, asserted that it was taken "to pass the night navigating through the depths of slumber."

The active principle in the root of *Mimosa hostilis* has been identified as N,N-dimethyltryptamine, the same constituent largely responsible for the psychoactive effects of the seeds of the related *Anadenanthera peregrina.*

Olmedioperebea: A narcotic snuff of the Pariana regions of the central Amazon of Brazil, known locally as *rapé dos indios* ("Indian snuff") is reputedly prepared from fruits of the moraceous jungle tree *Olmedioperebea sclerophylla.* Nothing is known of its chemical constituents.

Virola: Hallucinogenic snuffs—known as *epená*, *nyakwana*, *paricá* or *yakee*—are prepared in northwestern Brazil and adjacent Colombia and Venezuela from the red bark-resin of the myristicaceous genus *Virola.* At least three species are employed: *Virola calophylla* and *V. calophylloidea* in Colombia, *V. theiodora* in Brazil.

The most intense use of this snuff centres amongst the Waiká Indians of the uppermost sources of the

Fig. 7. *Banisteriopsis Caapi* cultivated by Barasana Indians. Río Piraparaná, Comisaría del Vaupés, Colombia. Photograph by R. E. Schultes.

Fig. 8. Tree of *Anadenanthera peregrina* in the *campos* or open grasslands near Bôa Vista, Rio Branco, Brazil. Photograph by R. E. Schultes.

Orinoco in Venezuela and along the northern tributaries of the Rio Negro in Brazil. Unlike the various Colombian tribes, where only witch-doctors take it, the intoxicant is employed amongst the Waiká by essentially all adult males, either individually at any time or ritually in excess at endocannibalistic ceremonies.

The method of preparing the snuff varies slightly, according to the tribe. In Colombia, the Indians usually strip the bark from jungle trees, scrape off the soft inner bark with its resinous exudation. This fresh tissue is kneaded and squeezed in water which is strained and boiled to a thick syrup. When the syrup is sun dried, it is pulverized, sifted and mixed with ashes of the bark of a wild species of cacao. Some Waiká in Brazil hang this soft inner bark material over the fire to dry slowly. When snuff is needed, they crush and pulverize this resin-containing tissue, add to it the pulverized leaves of the acanthaceous *Justicia pectoralis* var. *stenophylla* and bark ashes of the beautiful leguminous forest tree *Elizabetha princeps.* Still other groups of Waiká collect from freshly felled

Fig. 9. Snuffing tubes of bird bones and tray mortar and pestle for grinding roasted seeds of *Anadenanthera peregrina* and mixing with lime to prepare yopo snuff. Río Orinoco, Venezuela. Courtesy Botanical Museum of Harvard University.

Virola trees in the forest the resin itself, boil the resin down to a thick paste which, after sun-drying, is crushed, pulverized and utilized with no admixtures. The snuff made in this third way appears to be the most active.

Recent studies have indicated that the resins of a number of species of *Virola* possess tryptamines. The Waiká snuff prepared solely from resin of *Virola theiodora* contains several active tryptamines with the extremely psychoactive 5-methoxy, N,N-dimethyl-tryptamine in especially high concentrations.

Virola intoxication varies but usually includes initial excitability, numbness of the limbs, muscular incoordination, nausea, visual hallucinations and, finally, a deep disturbed sleep. Macroscopia—seeing things greatly enlarged—is frequent and enters into Waiká beliefs about *hikura*, the spirit dwelling in the *Virola* tree.

The Witoto, Bora and Muinane tribes of Amazonian Colombia utilize the resin of a *Virola*—possibly *V. theiodora*—orally as an hallucinogen. Small pellets of the boiled resin are rolled in a "salt"

Fig. 10. Makuna apprentice witch-doctor about to inhale snuff made from *Virola* resin through the bird-bone snuffing tube. Río Popeyaká, Comisaría del Amazonas, Colombia. Photograph by R. E. Schultes.

Fig. 11. Snuffing tubes and snail-shell snuff-box of the Makuna Indians, Río Piraparaná, Colombia. Courtesy Botanical Museum of Harvard University.

left upon evaporation of the filtrate of bark ashes of the lecythidaceous *Gustavia Poeppigiana* and ingested to bring on a rapid intoxication, during which the witch-doctors see and speak with "the little people." There are indirect suggestions, still to be corroborated by ethnobotanical field studies, that Venezuelan Indians may smoke *Virola sebifera* as an intoxicant.

Trichocereus: Several species of the South American cactus genus *Trichocereus* possess the hallucinogenic alkaloid mescaline. The large, columnar *T. Pachanoi* or *San Pedro* of the dry Andes of Ecuador and Peru is employed in magic and folk-medicine in northern Peru, where, together with another cactus, *Neoraimundia macrostibas* and *Isotoma longiflora*, *Pedilanthus titimaloides* and a species of *Datura*, it is the base of an hallucinogenic drink called *cimora*. The drink is taken by witch-doctors for diagnosis of disease, divination and "to make oneself owner of another's identity."

Lobelia: *Lobelia Tupa*, a tall polymorphic herb of the Andean highlands, known as *tupa* or *tabaco del diablo*, is widely recognized as toxic. The Mapuche Indians of Chile reputedly smoke the leaves of this campanulaceous species for their narcotic effect, but whether or not this effect is hallucinogenic is not yet known.

The leaves of tupa contain the piperidine alkaloid lobeline and the di-keto- and di-hydroxy-derivatives lobelamidine and neolobelamidine.

Gomortega: The Mapuche Indians of Chile may once have valued *Gomortega Keule*, known locally as *keule* or *hualhual*, as a narcotic, possibly as an hallucinogen. A very strict endemic belonging to the very small ranalean family Gomortegaceae, this tree has fruits that are reputedly intoxicating.

Coriaria: *Coriaria thymifolia*, long known in the Andes as toxic, has recently been reported as an hallucinogen, giving the sensation of flight. The fruits of this shrub, belonging to the Coriariaceae, are eaten for inebriation in Ecuador, where the plant is called *shanshi*. The effects are due apparently to catecholic derivatives.

Pernettya: The fruit of *Pernettya furiens*, known in Chile as *huedhued* or *hierba loca*, cause mental confusion and madness, even permanent insanity, and have a narcotic effect similar to that of *Datura*. This species seems not to have been chemically investigated, but its activity might be attributed to andromedotoxine or to arbutine, both present in many species of *Pernettya*.

In Ecuador, *Pernettya parvifolia*—locally called *taglli*—is known to be toxic, and its fruits, ingested, induce hallucinations and other psychic and motor alterations.

Desfontainia: The leaves of *Desfontainia spinosa* var. *Hookeri* are used in southern Chile as a narcotic and as a folk medicine under the name *taique*. Chemical studies apparently have not been carried out on this anomalous plant of the Desfontainiaceae, a family related to the Loganiaceae.

Iochroma: There are vague reports that several species of the solanaceous *Iochroma* may occasionally be utilized in the Colombian Andes for hallucinatory purposes. Further field work, however, must be done to substantiate these reports.

Fig. 12. Waiká Indian under the influence of *Virola* snuff. Maturacá, Rio Cauaburí, Brazil. Photograph by R. E. Schultes.

III.

It has been said that an outstanding characteristic of the present century will be the increasing use, abuse and misuse in sophisticated cultures of hallucinogenic substances. Drugs—and perhaps even hallucinogenic drugs—are here probably to stay in our western civilization, for better or for worse. One way of understanding them more thoroughly and sympathetically is to know their history and their roles in primitive societies. If for no other reason—and there are many others—we should strive to further our knowledge of native hallucinogens while there is still time to see and appreciate how man living intimately with his vegetal environment has evolved over thousands of years with his sacred hallucinogens.

Dr. J. R. Schramm Receives the Merit Award of the Botanical Society of America

This issue of the Morris Arboretum Bulletin honors Dr. J. R. Schramm who recently received for his distinguished long-term studies on the ecology of the black mining wastes of the anthracite region the highest award that the Botanical Society of America bestows.

Dr. Schramm has already served the Society as secretary, vice-president, and president; the University of Pennsylvania and the Philadelphia community as Professor of Botany and as Director of the Morris Arboretum (1939-1954). Science at large benefited from his deep knowledge of botanical literature and his extraordinary editorial skills as founder-editor of Biological Abstracts. But a great deal more is implicit in this new award from the Botanical Society, for it recognizes the value to everyone of his prolonged efforts to restore life to the countrysides that have been pillaged by industrial practices. These studies had first to divulge the aspects of environment that were inimical to the growth of plants: heat, lack of nitrogen, low pH, and related factors. Finally, they led to the recognition of symbiotic microorganisms that permit restoration of green plant growth, and at last, to successful practical applications. All hail.

Library Accessions

A manual of Plant Names. C. Chicheley Plowden. Philosophical Library. New York. 1969.

Andalusian Flowers and Countryside. C. M. Stocken. S. Devon, England. 1969.

Atlas Mycologique. Tome II. "Les Bolets". A. Leclair and H. Essette. Paul Lechevalier. Paris. 1969.

British Mosses and Liverworts. E. V. Watson. Cambridge Univ. Press. 1968.

Chemotaxonomy and Serotaxonomy. J. G. Hawkes. Academic Press. New York. 1968.

Crab Apples for America. Donald Wyman. The Amer. Assoc. of Bot. Gardens and Arboretums. 1955.

Design with Nature. Ian L. McHarg. The Natural History Press. Garden City. New York. 1969.

Disease Resistance in Plants. J. E. Van der Plank. Academic Press. New York. 1968.

Flora of Java. Vol. 3. C. A. Backer and R. C. Bakhuizen van den Brink. Wolters-Noordhoff N. V. Groningen. The Netherlands. 1968.

Flowers of Rumania. Rodica Rarau-Bichiceanu and Mircea Bichiceanu. Meridiane Pub. House. Bucharest. 1964.

Garden Flowers. Vishnu Swarup. National Book Trust. India. 1967.

Modern Methods of Plant Taxonomy. Ed. V. H. Heywood. Academic Press. New York. 1968.

Native & Naturalized Plants of Nantucket. Frank C. MacKeever. Edited by Harry E. Ahles. Univ. of Mass. Press. Amherst. 1968.

Ornamental Shrubs for Canada. L. C. Sherk and A. R. Buckley. Queen's Printer. Ottawa. 1968.

Plants of Central Florida. Henry S. Conard. Golden Rule Press. Orlando. 1969.

Pollen et Spores. Vols. I-X. Museum National D'Histoire Naturelle. Paris. 1959-1968.

Rhododendrons in America. Ted Van Veen. Sweeney, Krist & Dimm. Portland, Oregon. 1969.

Soil Biology. Ed. A. Burges and F. Raw. Academic Press. New York. 1967.

Spring Flora of Minnesota. Thomas Morley. Univ. of Minn. Press. 1969.

Textbook of Cytology. W. V. Brown and E. M. Bertke. C. V. Mosby Co. St. Louis. 1969.

The American Camellia Yearbook. Edited by Joseph H. Pyron. R. L. Bryan Co. Columbia, S.C. 1967.

The Book of Spices. Frederic Rosengarten, Jr. Livingston Publishing Co. Wynnewood, Pa. 1969.

The Gardeners' Yearbook. 1969. Ed. Philip Wilson. Collin Publishers. London. 1968.

The Golden Age of Plant Hunters. Kenneth Lemmon. Phoenix House. London. 1968.

The Paradoxical Nightshades. Chas. B. Heiser, Jr. W. H. Freeman & Co. San Francisco. 1969.

Trees for Southern Florida. David Sturrock. Central and Southern Florida Flood Control District, publisher. 1968.

Weeds of the World. Lawrence J. King. Interscience Publishers. N.Y. 1966.

Wildflowers of Cape Cod. Harold R. Hinds and Wilfred A. Hathaway. The Chatham Press. Old Greenwich, Conn. 1968.

Wild Flowers of the United States. Vol. 3, parts 1 and 2. Texas. H. W. Rickett. McGraw-Hill Book Co. New York. 1969.

Giant Dwarf of the Mesa Lands

Doyle Kline

When Spanish explorers entered the Southwest around 1500 A.D. they noted flat-topped hills and called them *mesas*, or tables.

They also found a squat, round tree growing on the hills that bore an edible nut. The tree resembled a pine. They called it *piñon*, or pine. Today the tree is known simply as *piñon.*

The Spanish noted also that a blue-gray jay without a topknot fed on the pine nuts, calling cheerfully from the treetops. They named him *piñonero*. In English, he is *piñon* jay.

The jays flock together in September at the close of their nesting season, and scout the piñon-covered hills for ripening nuts. They know, somehow, that piñon trees bear nuts somewhere every year.

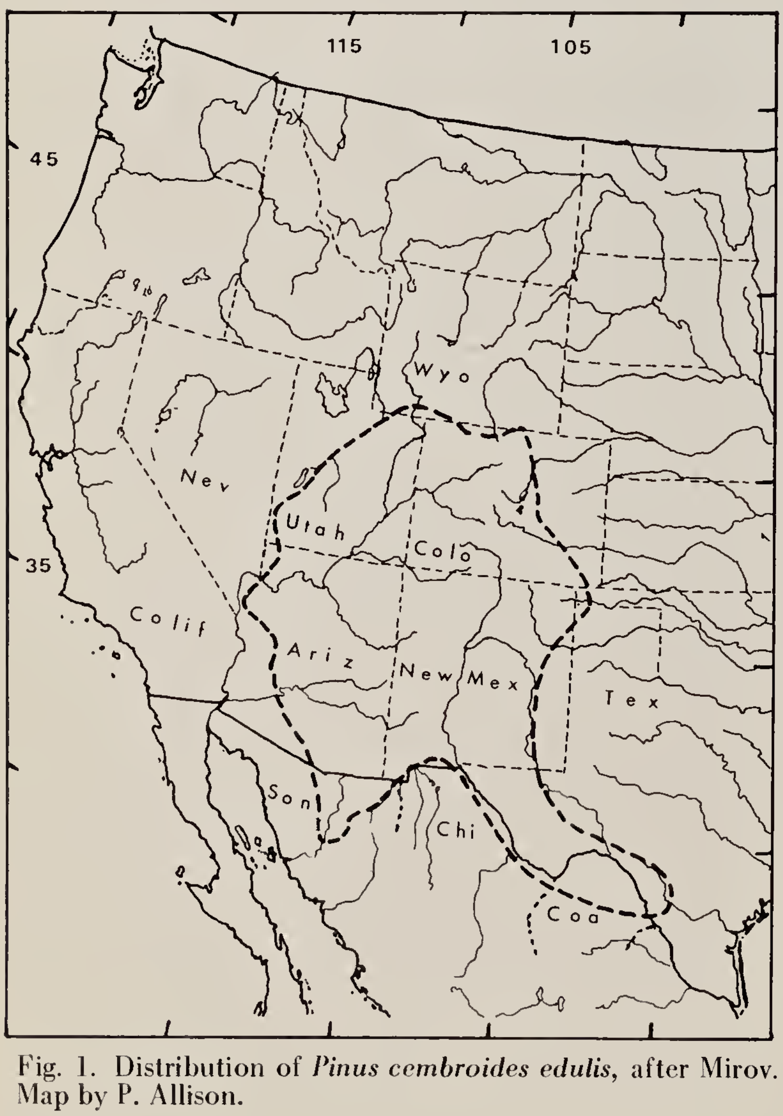

Fig. 1. Distribution of *Pinus cembroides edulis*, after Mirov. Map by P. Allison.

When they find a producing area, the jays peck at the opening cones, filling their stomachs and scattering coffee bean-sized nuts in the process. Also enjoying the harvest will be rodents, wild turkeys, and man. In addition, the tree has for centuries furnished fuel to man and shelter to wildlife.

The wood is excellent for cooking and heating. The incense of its smoke spells enchantment and nostalgia on autumn evenings in Santa Fe and small villages throughout most of the Southwest where people still cook with wood. Memories of such scents, blended with the aromas of fresh chili, tortillas, and frijoles, haunt anyone who has savored them.

Christmas, to many in the Southwest, would not be Christmas without a piñon Christmas tree or a gift of nuts.

Distribution and Characteristics

The early Spanish explorers did not know it then, but piñon pines covered thousands of square miles of open, arid lands throughout the West. The range of one kind occupies one fourth of New Mexico's area. Other western states also have large acreages of this species of pine. Or do they? There is more than one kind of nut pine. Some botanists regard the more important ones as varieties of *Pinus cembroides* Zucc. and so prefer the name *Pinus cembroides* Zucc. *edulis* (Engelm.) Voss for the Colorado Piñon Pine discussed here. Others refer to it as *Pinus edulis* Engelm.

At least eight separate species of piñon pines have been described. These are, according to Critchfield and Little:

1. *Pinus cembroides* Engelm. "Mexican pinyon"
2. *P. edulis* Engelm. "pinyon"
3. *P. quadrifolia* Parl. "Parry pinyon"
4. *P. monophylla* Torr. & Frém. "single-leaf pinyon"
5. *P. culminicola* Andresen & Beaman "Potosi pinyon"
6. *P. maximartinezii* Rzedowski "Martínez pinyon"
7. *P. pinceana* Gord. "Pince pinyon"
8. *P. nelsonii* Shaw "Nelson pinyon"

Fig. 2. *Pinus cembroides edulis* growing in its natural habitat as part of a pine-juniper woodland. Photo courtesy of Bureau of Land Management.

But, the ranges of 1 and 2 overlap, and 2 overlaps with 4. (To add to the complexity, a single-leafed form of 2 has been described! And there are forms of 4 intermediate with 2!) Species 3 also overlaps geographically with 4. Species 5, 7, and 8 are found growing in the same areas as 1. Indeed, the only mountain from which *P. culminicola* is known (at timber line, 3400-3600 meters) is clothed below with *P. cembroides*. The men who described *P. culminicola* mentioned that some of the specimens they included in the new concept had earlier been identified as *P. cembroides* Zucc. and *P. quadrifolia* Parry ex Parl.

The distribution of *P. cembroides edulis* in Figure 1 is the same as that mapped for *P. edulis* Engelm. by Mirov (Fig. 3-8, page 151). Mirov, as may be noted, shows the "Colorado piñon" in the Mexican States Sonora, Chihuahua, and Coahuila, but not in Baja California. In the text, however, the distribution to the south is "just across the border in the Mexican States of Baja California, Sonora, and Chihuahua." Critchfield and Little, who likewise recognize *P. edulis* as a distinct species, agree in general with Mirov regarding its distribution in the United States, but in their much more detailed map (No. 17) do not show it in Mexico at all. Both Martínez and Vines, who consider *P. edulis* as a variety of *P. cembroides*, point out the many intergrading forms and overlapping distribution with other representatives of the piñon pine group.

P. cembroides edulis grows slowly and rarely attains the height of 75 feet. Most are broadly pyramidal or globose, like that in Figure 2, although more upright forms, like the specimen at the Morris Arboretum (Fig. 3) are not rare. The number of short needles (¾-1¾ inches) in the fascicle is usually 2, but this is by no means constant. A surprising feature of the Colorado Piñon Pine is the small size of the globose cones (rarely more than 2 inches in length) that, for a pine, bear gigantic seeds (up to ¾ inch in

length) (Figs. 4, 5). The scales are few and only the central ones are fertile.

The trees grow principally at elevations of 5,000 to 7,000 feet. One wonders if the lower limit has been raised because of over harvest of seed or wood.

When young piñon trees begin to bear nuts, they may be 5 to 10 feet high and about 25 years old. At 75 years, the trees are big enough to produce nuts in commercial quantities. Adapted to the dry climate, they are long-lived and may continue to bear for hundreds of years. Old trees in good surroundings may grow to 75 feet and have a trunk diameter of 18 inches.

Fig. 4. Cones and nuts of ***Pinus cembroides edulis.*** Photo courtesy of Bureau of Land Management.

Harvesting

In September and October, usually after frost, the mature cones open and the nuts fall. The oldest and simplest method of harvesting is to pick the nuts off the ground by hand. A fast picker can harvest 20 pounds in one day. That's about 28,000 nuts!

Fig. 3. *Pinus cembroides edulis* at the Morris Arboretum. Photo by A. Heeps.

Sometimes pickers spread canvas beneath a tree loaded with expanding cones. They shake the tree, gathering the loosened nuts on the canvas. This is a pitchy undertaking at best. In the end it is slower than picking nuts from the ground. Piñon trees are copious producers of pitch. The cones are particularly gooey.

Other picking methods have been reported in other areas. None seems practical compared with the ancient Indian method. By picking pitch-free nuts off the ground, Indian women—who do most of the picking—need no ladders or other picking paraphernalia. On steep slopes such apparatus is more hindrance than help.

Average yield for New Mexico is about 1.5 million pounds of nuts a year. In 1936, a special study by New Mexico State University reported that 11.2 billion nuts, or about 8 million pounds, were produced that year in New Mexico, eastern Arizona, and southern Colorado.

Three successive growing seasons are necessary to produce mature cones, the University says. Thus, the piñon must have normal rainfall and other favorable conditions 3 years in a row to produce a good crop.

One of the advantages of the piñon nuts is their excellent keeping quality. Dry, unshelled nuts have been stored up to 3 years in New Mexico without turning rancid. Shelled nuts, however, turn rancid in 4 to 6 months. Apparently the nut will not become rancid as long as the germ retains its vitality. The nuts require dry air for proper curing, and should not be shipped to humid climates unless they are to be eaten right away. Roasting the nuts improves their flavor, but shortens keeping time. Eating raw nuts can cause

sore throats, according to some of our Indian acquaintances. We, therefore, always roast ours.

Roasting

The easiest way to roast the nuts is to place them unshelled in a cast iron frying pan over moderate heat on top of the stove. Don't try to roast too many at a time until you learn how. A cupful is a good start.

Let the nuts heat, stirring gently and constantly, for about 5 or 6 minutes. Taste a few kernels. Compare their taste and looks with unroasted kernels. Remember that the shells hold heat for a time and thus continue the roasting process after you remove the nuts from the pan. Allow for this. Roasting nuts in an oven is tricky. It is too easy to overdo it. Even Indians fail at this.

Researchers have found that the protein of the piñon nut has high biologic value. Beef round has a digestibility of 99.6 and a biologic value of 67.8. Piñon nut protein rates 94.4 and 63.3 respectively. That makes piñon nut protein superior to that of any nut except the cashew.

Piñon nut kernels average about 60 per cent fat. That is lower than the pecan, English walnut, and Brazil nut, which average about 70 per cent, but is higher than such nuts as the peanut, almond, and pistachio.

The kernel averages 58.1 per cent of the whole nut, leaving 41.9 per cent shell. Only the peanut has proportionately less shell.

The daily protein requirement of humans could be supplied by piñon nuts. The nuts also could supply 66 per cent of our calories, more than 200 per cent of our vitamin B_1, 170 per cent of our vitamin C, and 100 per cent of our iron.

Good nuts have a rusty brown color with shadings and mottlings of tan. Nuts with diseased or undeveloped kernels have a grayish cast. People wanting to gather and roast piñon nuts keep their eyes and ears on the piñon jays, watch for experienced gatherers along the roadsides, or study the trees directly during the appropriate seasons.

Westerners look upon the piñon tree as a friend. It clothes the weathered hills with softness, shelters wild animals against storms, feeds wildlife and humans with its rich nuts, warms the traveler before the fireplace, and cooks his meals. It corrals livestock, and shores up mineshafts with its timbers.

Fig. 5. ***Pinus cembroides edulis*** from "The Silva of North America" by Charles Sprague Sargent, artist C. E. Faxon. Reproduced with permission of Houghton Mifflin Company.

As if that were not enough, this giant dwarf of the mesa lands sends its incense up the chimney at Christmas time to lend enchantment to the land of the sagebrush and rimrock, to cheer the piñon jay through the snowy months, and to draw families together in traditions older than time.

Literature Cited

Andresen, John W. and John H. Beaman. 1961. A new species of Pinus from Mexico. Journ. of the Arnold Arb. 42: 437-441.

Critchfield, William B. and Elbert L. Little, Jr. 1965. Geographic distribution of the pines of the world. U.S. Dept. Agr. Misc. Pub. 991. 97 pp.

Martínez, Maximo. 1948. Los Pinos Mexicanos. 2nd ed. Ediciones Botas, Mexico. 361 pp.

Mirov, N. T. 1967. The Genus Pinus. Ronald Press Co., New York. 602 pp.

Vines, Robert A. 1960. Trees, Shrubs and Woody Vines of the Southwest. Univ. Texas Press, Austin. 1104 pp.

Recently, *Mr. De Marco* has very effectively constructed naturalistic wooden closures for Miss Morris' original log-cabin retreat adjacent to the creek. This installation was necessitated by occasional instances of vandalism.

We are pleased to announce that our "Index Seminum 1970", listing seeds of 93 taxa available for exchange, has been sent to over 500 addresses, largely Arboretums and Botanical Gardens, throughout the world.

Several interesting species of plants will be available for local Associates of the Arboretum on the traditional "Plant Distribution Days" which this year are scheduled for Friday, May 22nd, 9 A.M. until 4 P.M. and Saturday, May 23rd, 10 A.M. until noon. Identifying cards of instruction will be mailed by mid-May.

We regret to announce the passing, after a long illness, of Mrs. Margaret E. Tonkin on January 1, 1970. To Mr. John Tonkin and his family, all of the staff of the Arboretum extend their sincere sympathy.

The Staff

Dr. Li attended a "Conference on the Origin of the Soybean and the Systematics of *Glycine*" on February 21-22 at the University of Illinois, Urbana and also acted as the Systematist of the Conference. The Conference was sponsored jointly by the Crop Evolution Laboratory of the University of Illinois and the U. S. Department of Agriculture Regional Soybean Laboratory, Urbana.

On February 20th, the Board of Trustees of the Academy of Natural Sciences of Philadelphia appointed *Dr. Li* a Research Fellow. This is an honorary appointment in the Academy's Department of Botany.

During the spring semester, 1970, *Dr. Allison* is continuing research on the development of the basidiocarps of *Pseudocoprinus venustus* McKnight & Allison, and supervising the independent study of the fungi by Mrs. Dorothy Crandall in the Arboretum laboratory. *Dr. Allison* recently visited the Plant Industry Station at Beltsville, Maryland and the National Arboretum, Washington, D.C. to confer with authors of *Bulletin* articles, current and future.

In mid-December, *Mr. Heeps* had occasion to briefly visit the botanical and horticultural departments at Kew, Wisley, and Edinburgh. Of particular interest was the Threave School on Practical Gardening located in Castle Douglas, Kirkcudbrightshire because a year ago we had the pleasure of meeting Mr. William Hean, the Principal of the School, here during his brief visit to the Morris Arboretum.

Mr. Heeps and *Mr. Keyser* attended the four January and February sessions of the "Plant and Pest" Seminar sponsored by the Pennsylvania State Agricultural Extension Service.

Recently, *Mr. Heeps* has been appointed to membership on the Executive Committee for the Delaware Valley Horticultural Council. On February 9th he presented an illustrated lecture on "Trees and Shrubs for the Philadelphia Area" to the Springfield High School Adult Evening Class. "Some Common and Rare Trees and Shrubs as Possible Subjects for Flower Arranging" was the subject of a lecture which he presented to the Adult Evening Class of Eastern Montgomery Vocational Technical School on March 4th.

Dr. Dahl had the pleasure of a luncheon meeting with Mr. W. T. Hord, Vice-president of the First Pennsylvania Banking and Trust Company, on January 15th. We are delighted that Mr. Hord will be serving on the Advisory Board of Managers.

On February 20th, *Dr. Dahl* presented a lecture on "The Arboretum and the Herbarium" at the luncheon meeting of the Connoisseur's Club held at the Poor Richard Club, Philadelphia.

A. Orville Dahl

About Our Authors

Dr. Richard Evans Schultes is Executive Director of the Botanical Museum and Curator of Economic Botany at Harvard University. He is widely known for his distinguished researches in Latin American ethnobotany with specialized projects being devoted to critical analyses of narcotics and poisons used by primitive peoples. Dr. Schultes has engaged in many years of rewarding field work in South America. In addition he has published a number of his studies on the taxonomy of orchids and rubber-bearing plants.

H. Doyle Kline is the enthusiastic Assistant to the State Director, Bureau of Land Management, Santa Fe, New Mexico, and is thoroughly familiar with the importance and uses of the piñon nuts in Indian life. A shorter version of his article appeared in the Fall, 1969 issue of "Our Public Lands." Members of the Arboretum Staff contributed portions of the botanical section of the article published here.

Morris Arboretum Bulletin

LEGES SINE MORIBUS VANAE

Vol. 21 JUNE, 1970 Number 2

The European Turkey Oak, *Quercus cerris*, in the Morris Arboretum.

Published by

THE MORRIS ARBORETUM

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Arboretum Activities

Many choice varieties of cherries, peaches, apricots, and crab-apples in our collections have put on a profuse display of blossoms during the past two months. Quite notable for its charming flower form and superb fragrance is the all too rarely utilized "Japanese Apricot" (*Prunus mume* (Sieb.) Sieb. & Zucc.). This species has been used as the basis for the designs which grace many pieces of oriental porcelain. There are several selected forms including the fine cultivar 'Dawn.'

The remarkably fragrant "Winter Daphne" (*Daphne odora* Thunb.) experienced considerable winter damage although attractive flowering was evident on the lower branches of our specimen. Similar reaction to the past winter was exhibited by our unusual specimen of "Tea" (*Camellia sinensis* (L.) Ktze.). Both species are currently in vigorous new growth.

(Continued on Page 45)

The Big Trees of Southeastern Pennsylvania

John C. Swartley

Extraordinary trees exist in Southeastern Pennsylvania. The compilation of their names, dimensions and locations, originally made by Swartley and Hayden (15), for the International Shade Tree Conference, has recently been revised (16). Because the Morris Arboretum figures prominently in this compilation, it is now presented in augmented form to the readers of the *Bulletin* so that they may be able to enjoy the splendor of the numerous magnificent specimens growing in the area.

The territory covered is somewhat larger than that described by Samuel N. Baxter, then Horticulturist for the Fairmount Park Commission, in a paper at the Ninth Shade Tree Conference at the New York Botanical Garden in 1933, entitled "Notable Trees and Old Arboreta in and Around Philadelphia." His greatest range was from Andalusia to Longwood Gardens near Kennett Square. This has been augmented to include the old Moon Nursery planting, now Snipes' Farm and Nursery, Morrisville. Thus, the compilation covers roughly the counties of Bucks, Delaware, Philadelphia, Montgomery, and Chester. Many photographs of interesting specimens made during the study may be observed in the permanent display at Memorial Hall in the offices of the Philadelphia Street Tree Department.

The new list includes 255 species, varieties and hybrids. The number of individual trees is 386. Of this number, about 300 were observed and measured by the author. A few sets of data were furnished by individuals in letters and personal contacts. Most of the remaining records were taken from various publications by Mark Robinson of Media (14), 41 listings; and John T. McNeill, Jr. of Philadelphia (6,7,8), 26 listings; and Baxter (2). Over 150 trees on the list have either been known by the author for many years or were discovered by him after the search began. Also, many were found in following up suggestions of others. It was George Lewis who suggested we visit an Amur Cork Tree, five to six feet in diameter, in Penn Valley. In the vicinity we found eight more record trees. Most of this estate, formerly belonging to John Roberts, has been subdivided into expensive homesites.

It is interesting to analyze the list in other ways. Of the 255 different kinds, there are 99 in Philadelphia County, 60 in Delaware County, 54 in Montgomery County, 23 in Bucks County and 17 in Chester County. Of the 386 individual trees, almost half, 175, are growing on private properties. The remainder are growing on properties of public and private institutions. Of the arboreta in the area, the Morris Arboretum is first with 65 listings; the Tyler Arboretum is second with 18; and Longwood Gardens, third with 13. A veritable arboretum exists in the vicinity of the old Horticultural Hall site in Fairmount Park. From there we have 11 listings. Further study should uncover many more.

The most notable private estate from the standpoint of mature trees is that of John C. Haas, Spring Mill Road, Villanova. It formerly belonged to the Bodine family. Ten outstanding trees are listed from this estate, but there are in addition mature specimens of hemlock, English Beech, Cucumber Tree, Silver Linden and Little Leaf Linden growing there.

Probably the greatest concentration of notable trees is located along West Schoolhouse Lane in Germantown. For this area we have 20 listings. Our attention was called to this by the late Henry F. Riebe who, in 1955, prepared a paper on the subject for the Germantown Historical Society.

The old Moon Nursery, Morrisville, has made a significant contribution of 10 listings. According to records found by Bradford Snipes, a member of the Moon family, this collection was started in 1840.

Let us whet the appetite with a few dimensions. Probably the largest *Ulmus parvifolia*, the Chinese Elm, in the nation can be seen at the Morris Arboretum. It is nearly four feet in diameter 18 inches high. The most famous tree at the Tyler Arboretum in Delaware County is *Sequoiadendron giganteum*, the Sierra Redwood, three feet, two inches D. B. H. (diameter, breast high, i.e. 4½ feet). One of the notable trees at Longwood Gardens is *Magnolia cordata*, Yellow Cucumber Tree, three feet, five inches D. B. H. On the Haas estate is the largest tree of *Tilia petiolaris*, the Weeping Linden, four feet, ten inches D. B. H. On the Roberts Estate in Penn

Valley one of the four or five amazing trees is *Cercidiphyllum japonicum*, Katsura Tree, with a diameter of six feet, eight inches six inches above the ground. On West Schoolhouse Lane, one of the largest trees is a Purple Beech, *Fagus sylvatica atropunicea.* It measures six feet, eight inches in diameter at two feet. Behind it is a Sweetbay Magnolia, *Magnolia virginiana* 60 feet tall. It has multiple stems and is four feet, seven inches in diameter at six inches. The astonishing 6 feet, 5 inch *Platanus acerifolia* on Timber Lane is more than two feet larger in diameter than its closest rival. In the planting at Snipes' Farm and Nursery, the most extraordinary tree is an enormous specimen of *Cladrastis lutea*, the Yellowwood. It is a National Champion five feet, one inch D. B. H.

From the standpoint of size alone, the three largest trees in the area are specimens of *Platanus occidentalis*, the American Planetree (Moffett Nursing Home, Bucks County, nine feet, three inches, D. B. H.); *Quercus* x *Benderi*, a hybrid between Red Oak and Scarlet Oak (Van Seiver estate, Philadelphia County, seven feet six inches at thirty inches); and *Fagus sylvatica*, European Beech, (Gravers Lane and Prospect Avenue, Philadelphia, seven feet, five inches at 18 inches).

Probably the two rarest trees of unusual size are as follows: *Acer pycnanthum*, a low-headed Japanese plant related to *A. rubrum*, on the Haas estate, Villanova. The largest of three specimens measures one foot, five inches four feet above the ground. The other rare tree is *Picea orientalis pendula*, the Weeping Oriental Spruce, on Allens Lane, Philadelphia, one foot, one inch D. B. H. There are several others almost as rare.

A few outstanding trees are growing right at streetside in Philadelphia. The biggest is *Populus deltoides*, the Eastern Poplar, five feet five inches D. B. H. at 84th and Tinicum Streets. Next is a specimen of *Sophora japonica*, Japanese Pagoda Tree, three feet, ten inches D. B. H., on South Hobson Street. This is not included in the compilation because there are at least three larger trees of this species in the area. On Vernon Road, east of Chew Street, there is a famous planting of *Cedrela sinensis*, Chinese Cedrela. The renowned nineteenth century nurseryman, Thomas Meehan, is said to have planted these trees. The largest of the 29 is one foot, eleven inches D. B. H. Although they have been neglected, they are in remarkably good condition.

The American Forestry Association has been publishing "The Social Register of Big Trees," a list of the largest native and naturalized trees in the

Fig. 1. *Acer truncatum*, the Purpleblow Maple in one of the Japanese Gardens of the Morris Arboretum.

United States (4, 11, 12). Of the 385 National Champions, Michigan claimed 48, Pennsylvania only 7. Now, in the Philadelphia area we are claiming 23 National Champions. Not all have been officially accepted to date.

Recently, a booklet, "Big Trees of Pennsylvania," was published as a supplement to *Pennsylvania Forests* (9). The contribution from Southeastern Pennsylvania was significant. Of 86 trees included in the booklet, 50 were in the Philadelphia area. This is only the beginning. To qualify for credit in the competition for the champion of either the United States or Pennsylvania, the measurements must include the height and the average spread. This information was obtained for those trees that promised to be contenders for National Champions but not for possible Pennsylvania Champions. Of native and naturalized trees, possibly 49 in our list would qualify for Pennsylvania Champions. The Pennsylvania committee that prepared the supplement included only seven trees in the category of *exotic species and varieties.* About 169 in our list would be contenders if someone would revisit the trees to obtain the necessary additional measurements.

More than a year ago, there appeared a New Jersey compilation, "List of New Jersey's Biggest Trees" (10). This was a cooperative effort of the State Agricultural Extension Service and the U.S. Department of Agriculture. The largest of 76 different species and varieties, both native and exotic, were listed. Of these, ten were larger than any found in our list.

A few trees in our list are the same ones noted by Wildman (17). The following changes in size have taken place in a little less than 40 years: The Dilworthtown White Oak, *Quercus alba*, near West Chester, has grown from 5 feet, 9 inches to 6 feet, 10 inches in diameter at 30 inches. The Ware Cedar of Lebanon, *Cedrus libani*, near Oxford has grown from 3 feet, 2 inches to 4 feet, 7 inches, D. B. H. The Sierra Redwood, *Sequoiadendron giganteum*, at the Tyler Arboretum near Lima grew from 2 feet, 4 inches to 3 feet, 2 inches, D. B. H. Of course, Wildman was in error in listing the last two trees as Penn trees. Records indicate the Tyler tree could not have been planted much before 1860, and the Ware tree would certainly not be any older. McNeill (6) has done some checking of Penn trees that were noted by Wildman. He claims to have rediscovered over 20 of the Wildman trees. Most of these are oak, ash, and sycamore, all too small to appear on our list.

Most plants were introduced earlier than many people realize. Introduction dates were checked for 124 exotic species on the list (13): 33 were introduced "early" or before 1700; 16 between 1700 and 1800; 20 between 1800 and 1850; 41 between 1850 and 1900 and only 14 after 1900. This introduces a few enigmas! For example, the Katsura Tree in Penn Valley that measures six feet, eight inches in diameter belongs to a species that supposedly was introduced to cultivation in the United States in 1907. With few exceptions, records of planting dates are not available; yet numerous living patriarchs give proof of considerable activity in planting trees in this area in the late eighteenth and early nineteenth centuries. These are outnumbered by the many seemingly unusual trees that are actually not very old, and that were undoubtedly planted during the period of large estate founding in the late nineteenth and early twentieth centuries.

One wonders how many of these large native and exotic trees were planted on the recommendation of the late world-renowned landscape architect, Frederick Law Olmsted, who participated in the original planning of the Morris Arboretum (5).

THE BIG TREES[1]

ABIES CEPHALONICA—Greek Fir

2′11″;	Old neglected estate. Old York Road and County Line, Warminster, Montg. Co.
2′ 7″;	Old Moon Nursery, Morrisville, Bucks Co.
	This is the largest of several trees, until recently, wrongly identified as Abies nordmanniana.
2′ 4″;	Var. Apollinis. Morris Arboretum, Phila. Co.

ABIES CILICICA—Cilician Fir

2′ 4″;	Old John Evans Arboretum, Radnor, Del. Co.
2′ 2″;	Pendle Hill School, Nether Providence, Del. Co.
1′ 8″;	Morris Arboretum, Phila. Co.

[1] The botanical names are those cited in *Standardized Plant Names* (1). The authors associated with the specific combinations may be found in Fernald or Rehder (3, 13). Dimensions are diameters breast high unless otherwise specified. An asterisk indicates a tree that the American Forestry Association has accepted or is considering as the largest known specimen in the United States.

ABIES CONCOLOR—White Fir

2′ 9″;	Residence of James Large, Old Vare Estate, Morris Rd., Ambler, Montg. Co.
1′ 8″;	Roberts Estate, Penn Valley, Montg. Co.
1′ 5″;	Morris Arboretum, Phila. Co.

ABIES HOMOLEPIS—Nikko Fir

1′ 3″;	Morris Arboretum, Phila. Co.

ABIES LASIOCARPA—Alpine Fir

1′ 2″;	Morris Arboretum, Phila. Co.

ABIES NORDMANNIANA—Nordmann Fir

1′ 8″;	Snipes' Farm and Nursery, Morrisville, Bucks Co.
1′ 6″;	Morris Arboretum, Phila. Co.

ABIES SIBIRICA—Siberian Fir

2′ 6″;	Old John Evans Arboretum, Radnor, Del. Co.

ABIES VEITCHI—Veitch Fir

1′ 7″ at 48″; Morris Arboretum, Phila. Co.

ACER BUERGERIANUM—Trident Maple

2′ 5″ at 36″; Beaver College, Glenside, Montg. Co.
2′ 5″ at 6″; Morris Arboretum, Phila. Co.

Fig. 2. *Cercidiphyllum japonicum* the Katsura Tree, in the Morris Arboretum. This specimen has been admired by many visitors from other arboreta because of its lovely form.

ACER CAMPESTRE—Hedge Maple

3′ 5″ at 18″; 550 E. Evergreen Ave., Wyndmoor, Montg. Co.

Two horizontal limbs below the 18″ mark, measure 1′7″ and 1′3″ respectively, 18″ from the crotch.

1′10″; 330 Spring Mill Rd., Villanova, Montg. Co.

ACER CAPPADOCICUM—Coliseum Maple

2′ 6″; Tyler Arboretum, Middletown, Del. Co.

1′11″; 4180 Kottler Drive, Lafayette Hill, Montg. Co.

Largest of five trees in old Andorra nursery grounds.

1′11″; Green and Westview Sts., Germantown, Phila. Co.

1′10″ at 36″; Morris Arboretum, Phila. Co.

ACER CISSIFOLIUM
2′ 9″; Beaver College, Glenside, Montg. Co.

ACER HENRYI—Henry Maple
2′10″ at ground; Morris Arboretum, Phila. Co.

ACER MAYRI—Mayrs Maple
3′ 2″; Merion Botanical Park, Merion Station, Montg. Co.
2′ 9″ at 24″; Morris Arboretum, Phila. Co.
2′ 2″; Beaver College, Glenside, Montg. Co.

A. cappadocicum and A. mayri are closely related to each other and to A. platanoides.
A.c. is usually more tree-like than A.m.

ACER NEGUNDO—Ashleaf Maple
3′10″; John F. Ruckman Estate; Mechanicsville, Bucks Co.
3′ 9″ at 24″; Old John Evans Arboretum, Radnor, Del. Co.

ACER PALMATUM—Japanese Maple
2′ 5″ at ground; 3 Tohopeka Place, Chestnut Hill, Phila. Co.

ACER PALMATUM ATROPURPUREUM—Bloodleaf Maple
2′ 9″; 2′ 8″ at 12″; Kissinger property, East Tennis Avenue, Ambler, Montg. Co.

The color turns to green in early Summer on both trees.

ACER PALMATUM DISSECTUM ATROPURPUREUM—Threadleaf Maple
9″ at 24″; Wilmer Atkinson Estate, Butler Pike and Norristown Road, Three Tuns, Montg. Co.
8″; 232 Indian Creek Rd., Overbrook, Montg. Co.

This is one of a group.

ACER PLATANOIDES—Norway Maple
5′ 7″ at 3′; Quaker Cemetery, West Chester, Chester Co.
5′ 1″ at 24″; Old John Evans Arboretum, Radnor, Del. Co.

ACER PLATANOIDES SCHWEDLERI—Schwedler Norway Maple
3′ 3″; Old Morris Nursery, West Chester, Chester Co.

ACER PLATANOIDES CURCULLATUM—Crimped Norway Maple
2′ 0″; Marshall Square Park, West Chester, Chester Co.

ACER PSEUDOPLATANUS—Sycamore Maple
4′ 1″; 226 Indian Creek Rd., Overbrook, Montg. Co.
3′ 7″; Mt. Airy Presbyterian Church, Germantown Ave. and Mt. Pleasant, Phila. Co.

ACER PYCNANTHUM
1′ 5″ at 4′; 330 Spring Mill Rd., Villanova, Montg. Co.

This is the largest of three trees.

ACER RUBRUM—Red Maple
4′11″; Ridge Rd., S. of Rocky Hill Rd., Birmingham, Del. Co.

ACER SACCHARINUM—Silver Maple
6′11″; Lankenau School, 3202 W. Schoolhouse Lane, Germantown, Phila. Co.

A beautiful tree.

6′ 9″; Scott Tract, Abrahams Lane, Del. Co.
6′ 2″; F. R. F. Johnson Estate, near the springhouse, Gladwyne, Montg. Co.

ACER SACCARINUM WIERI—Cutleaf Silver Maple
3′ 0″; School of the Holy Child, 1344 Montgomery Ave., Rosemont, Montg. Co.
2′ 8″; Lankenau School, 3202 W. Schoolhouse Lane, Germantown, Phila. Co.

ACER SACCHARUM—Sugar Maple
4′ 9″; Rt. 32, 300′ S. of footbridge, Lumberville, Bucks Co.
4′ 0″; Borden Tract, Ridley Creek & Sycamore Mills Rds., Upper Providence, Del. Co.

ACER TRUNCATUM—Purpleblow Maple
1′ 9″ at 18″; Morris Arboretum, Phila. Co.

AESCULUS CARNEA—Red Horsechestnut
2′ 5″; Morris Arboretum, Phila. Co.

AESCULUS GLABRA—Ohio Buckeye
*3′ 0″; Morris Arboretum, Phila. Co.
2′ 3″; 4030 Timber Lane, off W. Schoolhouse Lane, Germantown, Phila. Co.

One of five trees.

AESCULUS HIPPOCASTANUM—Horse Chestnut
*4′ 2″; Newtown Square Inn, ½ mile south

of Newtown Square, Del. Co.
3'10"; 106 E. Court St., Doylestown, Bucks Co.

AESCULUS OCTANDRA—Yellow Buckeye
3' 2"; Haverford College, Del. Co.
3' 2"; Humphrey Marshall Homestead, Marshallton, Chester Co.

A tree with six trunks, 1'1" to 1'8"; Penn Charter School, Germantown, Phila. Co.

ALBIZZIA JULIBRISSIN—Mimosa, Silktree
*2 1"; Smith Estate, N. 7th St., Oak Lane, Phila. Co.

AILANTHUS ALTISSIMA—Tree of Heaven
3' 4"; Palmer's Mill Road and Paxon Hollow Road, Marple, Del. Co.

ALNUS GLUTINOSA—European Alder
1' 6"; Awbury Arboretum, Germantown, Phila. Co.

AMELANCHIER CANADENSIS—Serviceberry
1' 1"; Tyler Arboretum, Middletown, Del. Co.

BETULA ALLEGHANIENSIS—Gray Birch
4' 4" at 6"; Roberts Estate, Penn Valley, Montg. Co.

This tree has six trunks.

BETULA LENTA—Sweet Birch
3' 4"; Humphrey Marshall Homestead, Marshallton, Chester Co.
2' 6"; Longwood Gardens, Del. Co.

BETULA NIGRA—River Birch
*4' 4" at 26"; Awbury Arboretum, Germantown, Phila. Co.

A beautiful 4-trunk tree, the largest of a group.

BETULA PAPYRIFERA—Paper Birch
2' 9"; Horticultural Hall Grounds, Fairmount Park, Phila. Co.
2' 0"; Residence of R. Hollingworth, end of Timber Lane, Germantown, Phila. Co.

BETULA PENDULA—European White Birch
2' 2"; 3810 Oak Rd., Germantown, Phila. Co.

BETULA PENDULA LACINIATA—Cutleaf European White Birch
3' 5"; Red Barn Property, 200' from Fernhill Rd., West Chester, Chester Co.

BROUSSONETIA PAPYRIFERA—Paper Mulberry
*2' 6" at 36"; 4114 Timber Lane, off W. Schoolhouse Lane, Germantown, Phila. Co.

CARPINUS BETULUS—European Hornbeam
4' 1" at 12"; Off Montgomery Drive near Belmont Mansion, Fairmount Park, Phila. Co.
2' 4" at 12"; 622 E. Gravers Lane, Wyndmoor, Montg. Co.

CARPINUS CAROLINIANA—Ironwood
1' 1"; Pendle Hill School, Nether Providence, Del. Co.

CARPINUS JAPONICA—Japanese Hornbeam
2' 7" at 6"; Morris Arboretum, Phila. Co.

CARYA OVALIS—Red Hickory
3'11"; 8643 Montgomery Ave., Wyndmoor, Montg. Co.

CARYA OVATA—Shagbark Hickory
3' 6"; Rushland Rd., Wycombe, Bucks Co.

CASTANEA CRENATA—Japanese Chestnut
2' 2"; 139 Bethlehem Pike, Chestnut Hill, Phila. Co.

This is a beautiful tree about 50' high.

CASTANEA MOLLISSIMA—Chinese Chestnut
4' 0" at 24"; Wm. Tinsman property, Lumberville, Bucks Co.
2' 8" at 24"; Parking lot, Black Bass Hotel, Lumberville, Bucks Co.

These trees bear large nuts and are at least 100 years old.

CATALPA BIGNONIOIDES—Southern Catalpa
4'10"; Residence of Floyd Sandberg, Washington Ave., Wycombe, Bucks Co.

CATALPA BIGNONIOIDES NANA—Umbrella Catalpa
1'10"; 8510 Elliston Drive, Wyndmoor, Montg. Co.

CEDRELA SINENSIS—Chinese Cedrela
2' 2"; Midvale and McMichael, Germantown, Phila. Co.
1'11"; Largest of 29 trees on Vernon Rd., East of Chew St., Germantown, Phila. Co.

They were planted about 50 years ago by Thomas Meehan.

CEDRUS ATLANTICA—Atlas Cedar
2'10"; Jewish Home for the Aged, Old York Road above Wagner Ave., Phila. Co.

2′ 4″; Phila. College of Textiles and Science, Henry Ave. and W. Schoolhouse Lane, Germantown, Phila. Co.

CEDRUS ATLANTICA GLAUCA—Blue Atlas Cedar
2′ 6″; Morris Arboretum, Phila. Co.
2′ 5″ at 24″; 1200 Remington Rd., Narberth, Montg. Co.

Fig. 3. *Corylus colurna* on the Ambler Campus, Temple University. The Turkish Filbert has seldom been planted in the United States, hence this is an extraordinary specimen.

CEDRUS DEODARA—Deodar Cedar
2′ 0″; Crozer Theological Seminary, Upland, Del. Co.

This is the larger of two trees.

1′10″; Susquehanna Rd., between 309 Overpass and Fort Washington Ave. Montg. Co.

This tree was planted by the owner 35-40 years ago.

CEDRUS LIBANI—Cedar of Lebanon
4′ 9″ at 3′; Tyler Arboretum, Middletown, Del. Co.
4′ 7″; Ware property, Locust St., Oxford, Del. Co.

CELTIS LAEVIGATA—Mississippi Hackberry
2′ 4″; Horticultural Hall grounds, Fairmount Park, Phila. Co.

CELTIS OCCIDENTALIS—Hackberry
*5′ 8″ at 3″; Residence of Dr. Alderfer, E. Ashbridge and N. Franklin Sts., West Chester, Chester Co.

This tree may consist of two separate seedlings.

3′ 7″; 130 Radnor Ave., Radnor, Del. Co.
3′ 6″; Humphrey Marshall homestead, Marshallton, Chester Co.
3′ 5″; Site of old Cope Arboretum, Jewish Home for the Aged, Old York Rd., above Wagner Ave., Logan. Phila. Co.
3′ 4″; 330 Spring Mill Rd., Villanova, Montg. Co.

CEPHALOTAXUS FORTUNEI—Chinese Plumyew
3′ 1″ at 6″; Horticultural Hall Grounds, Fairmount Park, Phila. Co.

CERCIDIPHYLLUM JAPONICUM—Katsura Tree
6′ 8″ at 6″; Roberts Estate, Penn Valley, Montg. Co.

This tree has 15 trunks.

5′ 3″; 229 Rose Lane, Bryn Mawr, Montg. Co.
4′ 9″ at 12″; Morris Arboretum, Phila. Co.

CHAENOMELES LAGENARIA—Chinese Flowering Quince
2′ 0″ at 3″; Van Sciver Estate, Chestnut Hill, Phila. Co.
12″; Stanford Drive, Wynnewood, Montg. Co.

CHAMAECYPARIS NOOTKATENSIS PENDULA—Weeping Nootka Falsecypress
7″; Morris Arboretum, Phila. Co.

CHAMAECYPARIS OBTUSA—Hinoki Falsecypress
2′ 8″ at 27″; Haverford College, Del. Co.

This tree has two trunks with bark quite scaly.

1′11″; Snipes' Farm and Nursery, Morrisville, Bucks Co.

CHAMAECYPARIS PISIFERA—Sawara Falsecypress
2′ 3″; Tyler Arboretum, Middletown, Del. Co.

CHAMAECYPARIS PISIFERA PLUMOSA—Plume Sawara Falsecypress
3′ 2″ at 12″; 330 Spring Mill Rd., Villanova, Montg. Co.

CHAMAECYPARIS PISIFERA SQUARROSA—Moss Sawara Falsecypress
2′ 8″ at 24″; 330 Spring Mill Rd., Villanova, Montg. Co.

CHIONANTHUS VIRGINICUS—White Fringetree
8″; Tyler Arboretum, Middletown, Del. Co.

CLADRASTIS LUTEA—American Yellowwood
*5′ 1″; Snipes' Farm and Nursery, Morrisville, Bucks Co.

CORNUS CONTROVERSA—Giant Dogwood
1′ 5″ at 6″; Morris Arboretum, Phila. Co.

CORNUS FLORIDA—Flowering Dogwood
*2′ 1″ at 24″; Haverford College, Del. Co.
2′ 0″ at 24″; Friends Cemetery, Concordville, Chester Co.

CORNUS KOUSA—Chinese Dogwood
1′ 7″ at 12″; Westtown School Arboretum, Chester Co.

CORNUS MAS—Corneliancherry Dogwood
2′ 2″ at 12″; 6265 W. Valley Green Rd., Whitemarsh, Montg. Co.

CORYLUS COLURNA—Turkish Filbert
1′ 6″; Temple University, Ambler Campus, Montg. Co.

One of two trees, normally branched to the ground.
Comparatively free from troubles.

CRYPTOMERIA JAPONICA—Cryptomeria
1′11″ at 5′; Property adjoining 3240 W. Schoolhouse Lane, Germantown, Phila. Co.

CRYPTOMERIA JAPONICA LOBBI—Lobb Cryptomeria
1′ 2″; Tyler Arboretum, Middletown, Del. Co.

Also an avenue of about 80 trees, largest 1′1″ dia.; Old Andorra Nurseries, Lafayette Hill, Montg. Co.

CUNNINGHAMIA LANCEOLATA—China Fir
2′10″ at ground; Far Country, Kitchens Lane, Mt. Airy, Phila. Co.

Was killed to ground in 1934.

DAVIDIA INVOLUCRATA—Dovetree
1′ 7″ at 3″; 215 Weldy Ave., Oreland, Montg. Co.

This tree has two trunks.

1′ ½″; Barnes Foundation, Merion, Montg. Co.

DIOSPYROS VIRGINIANA—Persimmon
3′ 3″ at 1′; Ardmore Methodist Church, Argyle and Athens Aves., Ardmore, Montg. Co.

This tree has three trunks and is a beautiful specimen.

EUCOMMIA ULMOIDES—Hardy Rubber Tree
2′ 0″ at 24″; Morris Arboretum, Phila. Co.

There are two other trees about the same size in the Tyler Arboretum and the Westtown School Arboretum.

EUONYMUS BUNGEANA—Winterberry Euonymus
2′ 4″; 2′ 3″; Woodward Estate, St. Martin's Lane, Chestnut Hill, Phila. Co.

The larger of these two trees is 60′ high.

EVODIA DANIELLI—Korean Evodia
2′ 3″ at 36″; Morris Arboretum, Phila. Co.

Much publicized as a "Bee Tree." Another tree stands nearby with three separate trunks, each about 1′5″ in diameter.

FAGUS AMERICANA—American Beech
5′ 2″; Pendle Hill School, Nether Providence, Del. Co.
5′ 0″; Friends Central School Woods, end of Green Hill Rd., Overbrook, Montg. Co.

FAGUS ENGLERIANA—Engler Beech
3′ 4″ at 12″; Morris Arboretum, Phila. Co.

This tree branches very close to the ground.

FAGUS SYLVATICA—European Beech
7′ 5″ at 18″; Gravers Lane & Prospect, Chestnut Hill, Phila. Co.

This is the most overwhelming tree in the Philadelphia area.

6′ 8″ at 12″; 215 Lynnbrook Lane, Chestnut Hill, Phila. Co.
6′ 8″ at 6″; 311 Rosemary Lane, Penn Valley, Montg. Co.

6' 7" at 24"; 4030 Timber Lane, Germantown, Phila. Co.

FAGUS SYLVATICA ASPLENIFOLIA—Fernleaf Beech

4' 4" at 24"; 8304 Stenton Ave., Chestnut Hill, Phila. Co.

This may be technically var. laciniata since the leaves are not deeply cut.

FAGUS SYLVATICA ATROPUNICEA—Purple Beech

6' 8" at 24"; 3464 W. Schoolhouse Lane, Germantown, Phila. Co.

5'11"; Snipes' Farm and Nursery, Morrisville, Bucks Co.

5' 8" at 18"; Morris Arboretum, Phila. Co.

FAGUS SYLVATICA CUPREA—Copper Beech

5' 9" at 2'; Quaker Cemetery, West Chester, Chester Co.

5' 8"; 380 N. Highland Ave., Merion, Montg. Co.

FAGUS SYLVATICA PENDULA—Weeping European Beech

3' 6" at 2'; Old Morris Nursery, West Chester, Chester Co.

This tree has 6 trunks from layers, 9-17" in diameter.

2' 4" at 12"; Cherokee Apts., Chestnut Hill, Phila. Co.

This is a remarkable tree because it has 15 auxiliary trunks from layered branches, ranging from 3½" to 11" diam. Also, extensive construction was done by Lewis Tree Surgeons when grades were drastically altered.

FAGUS SYLVATICA—(Pendulous type)

4' 3"; Lankenau School, W. Schoolhouse Lane, Germantown, Phila. Co.

3' 8" at 30"; Morris Arboretum, Phila. Co.

3' 0"; Boy Scout Center, Elkins Park, Montg. Co.

These three trees are very much alike and may possibly be the same clon. They are half weeping.

FAGUS SYLVATICA ROSEO—MARGINATA—Rosepink Beech

1' 4"; Beaver College, Glenside, Montg. Co.

FAGUS SYLVATICA ROTUNDIFOLIA—Roundleaf Beech

2' 5"; Beaver College, Glenside, Montg. Co.

FRANKLINIA ALATAMAHA—FranklinTree

*1' 3" at 3"; 622 E. Gravers Lane, Wyndmoor, Montg. Co.

This tree is approximately 25' high and 30' wide.

FRAXINUS AMERICANA—White Ash

*7' 7"; Between Chester Creek and Creek Road in meadow next to Glen Mills Elementary School, Glen Mills, Del. Co.

5' 9"; Westtown School, Chester Co.

FRAXINUS EXCELSIOR—European Ash

3' 1"; 614 E. Gravers Lane, Wyndmoor, Montg. Co.

This tree is 75' high and 120' wide.

FRAXINUS ORNUS—Flowering Ash

1' 7"; Westtown School Arboretum, Chester Co.

1' at 30"; Temple University, Ambler Campus, Montg. Co.

FRAXINUS PLATYPODA

1' 3"; Morris Arboretum, Phila. Co.

Fig. 4. *Diospyros virginiana*, the native persimmon, near the Ardmore Methodist Church. Note the interesting bark and the yard stick.

FRAXINUS QUADRANGULATA–Blue Ash
- 2′ 2″; Barnes Foundation, Merion, Montg. Co.

GINKGO BILOBA–Ginkgo
- 5′ 8″ at 12″; Tyler Arboretum, Middletown, Del. Co.
- 5′ 7″ at 18″; Montgomery Court Apartments, N. Narberth Ave., Narberth, Montg. Co.
- 5′ 2″ at 48″; 3240 W. Schoolhouse Lane, Germantown, Phila. Co.

GINKGO BILOBA FASTIGIATA–Sentry Ginkgo
- 2′10″; Barnes Foundation, Merion, Montg. Co.
- 2′ 9″; Horticultural Hall Grounds, Fairmount Park, Phila. Co.

  This is the original plant of the well-known cultivar, Fairmount, a male with good growth habit.
- 2′ 7″; Snipes' Farm and Nursery, Morrisville, Bucks Co.

GLEDITSIA AQUATICA–Water Locust
- *2′ 5″; Papermill Rd. and Montgomery Ave., Wyndmoor, Montg. Co.

  This is one of 3 trees, pods have a single seed.

GLEDITSIA TRIACANTHOS–Honey Locust
- 4′ ; Tyler Arboretum, Middletown, Del. Co.
- 3′ 7″; Ravenhill School, 3480 W. Schoolhouse Lane, Germantown, Phila. Co.
- 3′ 3″; Old Rodman-Patton property, Rte. 413, Flushing, Bucks Co.

GYMNOCLADUS DIOICUS–Kentucky Coffee Tree
- *4′ 7″; R. H. Decker Residence, 3728 Darby Rd., Bryn Mawr, Del. Co.
- 4′ 5″; 330 Spring Mill Rd., Villanova, Montg. Co.
- 3′ 9″; Cann Residence, Marshallton, Chester Co.
- 3′ 8″; Longwood Gardens, Chester Co.

HALESIA CAROLINA–Carolina Silverbell
- *3′ 6″ at 18″; 8510 Elliston Drive., Wyndmoor, Montg. Co.

HALESIA MONTICOLA–Mountain Silverbell
- 2′10″ at 12″; 429 Chestnut Hill Ave., Phila. Co.

HALESIA MONTICOLA VESTITA–Fuzzyleaf Silverbell
- 1′11″; Morris Arboretum, Phila. Co.

HOVENIA DULCIS–Raisintree
- 3′ 0″ at ground; Morris Arboretum, Phila. Co.

  This tree has two diverging trunks just above ground level.

ILEX OPACA–American Holly
- 3′ 4″ at 3″; Longwood Gardens, Del. Co.

  This is a three-trunk male.

JUGLANS CINEREA–Butternut
- 3′ 3″; Between Taylor Rd. and Neshaminy Creek, Hulmesville, Bucks Co.

JUGLANS NIGRA–Black Walnut
- 4′ 8″; Old Moon Property, Buckingham Way, Morrisville, Bucks Co.
- 4′ 6″; 336 Aubrey Rd., Wynnewood, Montg. Co.
- 4′ 5″; Library Tract, Upper Darby, Del. Co.

KALOPANAX PICTUS
- 2′ 4″; Horticultural Hall Grounds, Fairmount Park, Phila. Co.

  This is related to Acanthopanax and is a very fine plant.

KOELREUTERIA PANICULATA–Golden Raintree
- 2′ 2″ at 18″; Ellis School, Newtown Square, Del. Co.
- 1′ 6″; Willaman Residence, Plymouth Meeting, Montg. Co.

LARIX DECIDUA–European Larch
- *3′ 4″; Church of the Redeemer, Pennswood and Fisher Rds., Montg. Co.
- 2′ 7″; 330 Spring Mill Rd., Villanova, Montg. Co.
- 2′ 5″; Longwood Gardens, Del. Co.

LARIX DECIDUA X LEPTOLEPIS–Hybrid Japanese Larch
- 2′ 5″ at 5′; Morris Arboretum, Phila. Co.

LARIX LARICINA–American or Eastern Larch–Tamarack
- 2′ 6″; Tyler Arboretum, Middletown, Del. Co.

LARIX LEPTOLEPIS–Japanese Larch
- 2′11″; Barclay Old Folks' Home, N. Church St., West Chester, Chester Co.

LIBOCEDRUS DECURRENS–California Incense-cedar
- 1′11″; Longwood Gardens, Del. Co.

1′ 5″;	Old John Evans Arboretum, Radnor, Del. Co.

This tree is green only at the top on account of competition.

LIQUIDAMBAR STYRACIFLUA—American Sweet-gum

3′11″;	Curtis Arboretum, Wyncote, Montg. Co.
3′10″;	301 Maryland Ave., Aldan, Montg. Co.
3′ 2″;	8765 Montgomery Ave., Wyndmoor, Montg. Co.
3′ 1″ at 4′;	3240 Schoolhouse Lane, Germantown, Phila. Co.

LIRIODENDRON TULIPIFERA—Tuliptree

6′ 7″;	Robinson tract on Winding Lane, Nether Providence, Del. Co.
6′ 0″;	806 Glen Rd., Glenside, Montg. Co.
5′11″;	"Kirkbride" H. H. Smith property, Ferry Ave., Morrisville, Bucks Co.
5′10″;	Tyler Arboretum entrance, Del. Co.

MACLURA POMIFERA—Osage Orange

3′11″;	Lutheran Theological Seminary, Mt. Airy, Phila. Co.

MAGNOLIA ACUMINATA—Cucumbertree

4′ 3″;	Crozer Theological Seminary, Upland, Del. Co.
4′ 3″ at 1′;	Friends Meeting Cemetery, Nether Providence, Del. Co.

MAGNOLIA CORDATA—Yellow Cucumbertree

*3′ 5″;	Longwood Gardens, Del. Co.

MAGNOLIA DENUDATA—Yulan Magnolia

2′ 5″;	Tyler Arboretum, Middletown, Del. Co.

MAGNOLIA FRASERI—Fraser's Magnolia

*3′ 0″;	Lutheran Theological Seminary, 7301 Germantown Ave., Phila. Co.
2′ 7″ at 12″;	8750 Montgomery Ave., Wyndmoor, Montg. Co.

This is a multi-stem plant.

MAGNOLIA GRANDIFLORA—Southern Magnolia

1′ 6″;	Longwood Gardens, Del. Co.
1′ 3″;	941 Kedron Ave., Ridley, Del. Co.

MAGNOLIA KOBUS—Kobus Magnolia

2′ 2″ at 2′;	Longwood Gardens, Del. Co.

MAGNOLIA LILIFLORA GRACILIS—Lily Magnolia

1′11″ at 12″;	Lankenau School, W. Schoolhouse Lane, Germantown, Phila. Co.

This has layered itself and forms a broad pendant plant about 20′ high and 45′ wide.

MAGNOLIA MACROPHYLLA—Bigleaf Magnolia

1′11″;	3939 Netherfield Rd., Germantown, Phila. Co.
1′ 9″ at 30″;	Morris Arboretum, Phila. Co.

MAGNOLIA SOULANGEANA—Saucer Magnolia

Tree with three trunks about 1′ diameter at 18″, opposite 716 Davidson Rd., Cherokee Apts. Chestnut Hill, Phila. Co.

Fig. 5. *Malus pumila.* This incredible specimen of apple tree grows in Chestnut Hill.

MAGNOLIA STELLATA—Star Magnolia

2′ 4″ at 3′;	Roberts Estate, Penn Valley, Montg. Co.

The largest of 9 plants in a group has 3 trunks. The measurement was taken on the largest trunk. There is no doubt this is the oldest planting in the area.

MAGNOLIA TRIPETALA—Umbrella Magnolia

*3′ 1″ at 24″;	Wm. Tinsman property, Lumberville, Bucks Co.

This has multiple stems from the ground.

MAGNOLIA VIRGINIANA–Sweetbay Magnolia

4′ 7″ at 6″; 3464 W. Schoolhouse Lane, Germantown, Phila. Co.

1′10″ at 3′; Longwood Gardens, Del. Co.

MAGNOLIA VIRGINIANA–'Henry Hicks'

0′10″; Swarthmore College, Del. Co.

This is an evergreen cultivar.

MALUS PUMILA–Apple

2′ 9″; 7921 Germantown Ave., Chestnut Hill, Phila. Co.

METASEQUOIA GLYPTOSTROBOIDES–Dawn Redwood

1′10″ at 18″; Longwood Gardens, Del. Co.

MORUS RUBRA–Red Mulberry

4′ 6″; Residence of Philip G. Nordell, Evans Rd., Ambler, Montg. Co.

NYSSA SYLVATICA–Sour Gum

4′ 3″; Tinker Hill Farm, Phoenixville, Chester, Co.

3′10″; Heyburn & Smith Bridge Rds., Birmingham, Del. Co.

3′ 0″; 401 Mulberry Lane, Bryn Mawr, Montg. Co.

OSTRYA VIRGINIANA–American Hophornbeam

2′ 2″ at 12″; 324 Tower Rd., Penn Valley, Montg. Co.

This is the larger of two double trunk trees.

1′ 6″ at 2′; Morris Arboretum, Phila. Co.

OXYDENDRUM ARBOREUM–Sorrel Tree

2′ 0″ at 42″; 330 Rosemary Lane, Penn Valley, Montg. Co.

1′10″; Snipes' Farm and Nursery, Morrisville, Bucks Co.

PARROTIA PERSICA–Persian Parrotia

2′ 0″ at ground; Tyler Arboretum, Middletown, Del. Co.

PAULOWNIA TOMENTOSA–Royal Paulownia

*6′ 5″; 230 W. Allen's Lane, Mt. Airy, Phila. Co.

5′ 3″; Phila. College Textiles & Science, Phila. Co.

PHELLODENDRON AMURENSE–Amur Corktree

5′ 9″; Roberts Estate, Penn Valley, Montg. Co.

PHELLODENDRON JAPONICUM–Japanese Corktree

2′ 6″; Morris Arboretum, Phila. Co.

Fig. 6. *Phellodendron japonicum*, the Japanese Cork Tree, in the Morris Arboretum.

PHELLODENDRON LAVALLEI–Lavalle Corktree

3′ 2″ at ground; 139 Bethlehem Pike, Chestnut Hill, Phila. Co.

This has extremely glossy, dark green leaves and is low-branched.

1′ 5″ at 12″; Morris Arboretum, Phila. Co.

PICEA ABIES–Norway Spruce

3′ 6″; Residence of R. B. Collins, off Morris Rd., Ambler, Montg. Co.

3′ 2″; Jordan Tract, Nether Providence, Del. Co.

PICEA ABIES INVERSA–Drooping Norway Spruce

10″, largest of 3; 1704 Penns Lane, Ambler, Montg. Co.

Planted in a group.

PICEA BICOLOR–Alcock Spruce

1′ 0″; Morris Arboretum, Phila. Co.

PICEA MAXIMOWICZI–Maximowicz Spruce

1′ 6″; Morris Arboretum, Phila. Co.

PICEA ORIENTALIS–Oriental Spruce

2′ 8″; Tyler Arboretum, Middletown, Del. Co.

PICEA ORIENTALIS PENDULA—Weeping Oriental Spruce
1′ 1″; 937 Allen's Lane, Germantown, Phila. Co.

PICEA POLITA—Tigertail Spruce
1′ 4″; Morris Arboretum, Phila. Co.

PICEA PUNGENS GLAUCA—Colorado Blue Spruce
1′ 7″; Morris Arboretum, Phila. Co.

PINUS AYACAHUITE—Mexican White Pine
2′ 4″; Beaver College, Glenside, Montg. Co.
There is another large one at Westtown School.

PINUS BUNGEANA—Lacebark Pine
A tree with 4 upright trunks,
6-19″ at 18″; Morris Arboretum, Phila. Co.
This has branched below ground level, therefore it is impossible to measure the "trunk."

PINUS CEMBRA—Swiss Stone Pine
1′ 5″; Swarthmore College, Del. Co.

PINUS CEMBROIDES EDULIS—Colorado Pinyon Pine
1′ 1″; Morris Arboretum, Phila. Co.

PINUS FLEXILIS—Limber Pine
1′ 5″; Longwood Gardens, Del. Co.

PINUS GRIFFITHI (P. WALLICHIANA)—Himalayan Pine
5′ 4″ at 24″; Next to James' House, Indian Lane, Middletown, Del. Co.
This tree has four large trunks.
3′ 2″; Wister and Clarkson Sts., Germantown, Phila. Co.
Planted in 1873 or '74 by John C. Wister's father.
2′10″; Morris Arboretum, Phila. Co.

PINUS LAMBERTIANA—Sugar Pine
2′11″; Landover & Coopertown Rds., Bryn Mawr, Del. Co.
This is probably the largest Sugar Pine in the East.

PINUS NIGRA AUSTRIACA—Austrian Pine
3′ 0″; Ruckman Estate, Mechanicsville, Bucks Co.

PINUS PALUSTRIS—Long Leaf Pine
0′11″; Morris Arboretum, Phila. Co.
For about 10 years after planting, this was protected in the winter with an open end box.

PINUS QUADRIFOLIA
1′ 2″; Tyler Arboretum, Del. Co.
This name is according to Sudworth.

PINUS RIGIDA—Pitch Pine
2′ 0″; Meredith Allen Estate, Narcissa Rd., Ambler, Montg. Co.

PINUS STROBUS—White Pine
3′ 9″ at 20″; 330 Spring Mill Rd., Villanova, Montg. Co.
This tree has four trunks.
3′ 7″; Tyler Arboretum, Middletown, Del. Co.
3′ 7″; McElroy Property, N. Church St., West Chester, Chester Co.

PINUS SYLVESTRIS—Scots Pine
2′10″; Royahn residence, Rt. 202 S.W. of New Britain, Bucks Co.

PINUS TABULAEFORMIS—Chinese Pine
1′ 9″ at ground; Morris Arboretum, Phila. Co.

PINUS THUNBERGI—Japanese Black Pine
1′10″; Largest in group of 5 at Dr. Regelman's residence, Meetinghouse Rd., Hartsville, Bucks. Co.
These plants are extremely picturesque.

PLATANUS ACERIFOLIA—London Planetree
6′ 5″; 4120 Timber Lane, Germantown, Phila. Co.
4′ 2″; Woodlands Cemetery, West Phila., Phila. Co.
3′ 9″; 330 Spring Mill Rd., Villanova, Montg. Co.
3′ 6″; Fairmount Park, Old Horticultural Hall Grounds, Phila. Co.
A mature Planetree is very imposing.

PLATANUS OCCIDENTALIS—American Planetree
9′ 3″; Moffet Nursing Home, Newportville Road, S. of Flushing Rd., Bucks Co.
7′ 6″ at 30″; Mathers Mill Rd., Whitemarsh, Montg. Co.
7′ 0″; Righter's Mill Rd. and Mill Creek Ford, Gladwyne, Montg. Co.

POPULUS DELTOIDES—Eastern Poplar
5′ 5″; 84th & Tinicum Sts., Phila. Co.

PRUNUS AVIUM—Mazzard Cherry

*6' 3"; Glen Mills School, Thornbury, Del. Co.

3' 3" at 24"; 1016 Church Rd., Wyncote, Montg. Co.

This is similar to an Oxhart, but the fruits are smaller.

PRUNUS SEROTINA—Black Cherry

3'11"; Crozer Theological Seminary, Upland, Del. Co.

PRUNUS SERRULATA (Double Pink)—Oriental Cherry

1'11" at 26"; 424 W. Springfield Ave., Chestnut Hill, Phila. Co.

PRUNUS SUBHIRTELLA PENDULA—Weeping Oriental Cherry

2' 9" at 4'; Marshall Square Park, West Chester, Chester Co.

PRUNUS YEDOENSIS—Yoshino Cherry

2' 7"; Morris Arboretum, Phila. Co.

PSEUDOLARIX AMABILIS—Golden Larch

2' 3"; Horticultural Hall Grounds, Fairmount Park, Phila. Co.

1' 9"; Westtown School Arboretum, Chester Co.

1' 8"; Boy Scout Center, Elkins Park, Montg. Co.

There are two trees in the woods at turn of drive.

PTEROCELTIS TATARINOWII—Tatar Wingceltis

2'10" at ground—Multiple trunks; Morris Arboretum, Phila. Co.

PYRUS CALLERYANA—Callery Pear

2' 5" at ground; Morris Arboretum, Phila. Co.

PYRUS COMMUNIS—Common Pear

1'10"; Powel House, 244 S. 3rd St., Phila. Co.

PYRUS 'KIEFFER'—Kieffer Pear

1' 8"; Valley Green Farm, Shawmont Ave., Roxborough, Phila. Co.

QUERCUS ALBA—White Oak

6'10" at 3'; Brinton's Bridge Road, West Chester, R.D. #5, Chester Co.

6' 5"; Rte. 363, King of Prussia, Montg. Co., back of the Howard Johnson restaurant.

QUERCUS ALBA X ROBUR

1' 9"; Residence of Mrs. Morris Roosevelt, Mann Rd., Horsham, Montg. Co.

This is an unusual hybrid, one of two trees.

QUERCUS ALIENA—Oriental White Oak

1' 8"; Morris Arboretum, Phila. Co.

QUERCUS X BEBBIANA (White O. X Bur O.)—Bebb Oak

*3' 0"; Morris Arboretum, Phila. Co.

QUERCUS X BENDERI (Eastern Red O. X Scarlet O.)—Bender Oak

7' 6" at 30"; Van Sciver Estate, Chestnut Hill, Phila. Co.

This is a very awe-inspiring tree.

4' 4" at 36"; Morris Arboretum, Phila. Co.

QUERCUS BICOLOR—Swamp White Oak

5' 1"; Pole Cat & Ivy Rds., Concord, Del. Co.

4' 8"; 382 N. Keswick Ave., Glenside, Montg. Co.

QUERCUS BOREALIS MAXIMA—Red Oak

7' 0"; Gradyville Rd., Jefford Tract, Edgmont, Del. Co.

QUERCUS CERRIS—European Turkey Oak

4' 3"; 18 N. Norwinden Drive, Springfield, Del. Co.

Fig. 7. The *Sophora japonica* that once graced the Morris Arboretum. It finally succumbed to hurricane and lightning damage.

4′ 2″; Morris Arboretum, Phila. Co.

QUERCUS COCCINEA—Scarlet Oak
*3′10″; Swarthmore College, Del. Co.

This tree was nominated for National Champion in 1963 by Robinson, but not listed in (14). It may be a black oak.

QUERCUS DENTATA—Daimyo Oak
1′ 3″; Morris Arboretum, Phila. Co.

QUERCUS FALCATA—Southern Red Oak or Spanish Oak
3′ 4″; Near Rutgers Ave. and S. Chester Rd., Swarthmore, Del. Co.

QUERCUS X HETEROPHYLLA (Eastern Red O. X Willow O.)—Bartram Oak
*3′11″; Humphrey Marshall Homestead, Marshallton, Chester Co.
2′ 0″; Residence of Mrs. Morris Roosevelt, Mann Rd., Horsham, Montg. Co.

QUERCUS IMBRICARIA—Shingle Oak
3′ 4″; Snipes' Farm and Nursery, Morrisville, Bucks Co.
2′10″; Ardmore Methodist Church, Argyle and Athens Aves., Ardmore, Montg. Co.

QUERCUS LIAOTUNGENSIS
1′ 7″; Morris Arboretum, Phila. Co.

QUERCUS LYRATA—Overcup Oak
2′ 3″; Morris Arboretum, Phila. Co.

QUERCUS MACROCARPA—Bur Oak
5′ 2″; Friends Central School, Phila. Co.
4′ 8″; Snipes' Farm and Nursery, Morrisville, Bucks Co.
4′ 6″; Haverford College, Del. Co.

QUERCUS MARILANDICA—Blackjack Oak
2′ 0″; Easton & Edgehill Rds., Roslyn, Montg. Co.

QUERCUS MICHAUXI—Yellow Chestnut Oak
4′ 5″; Haverford College, Del. Co.
4′ 3″; Street Rd., Rte. 132, about ¾ mi. east of Rte. 1, Bucks Co.
3′ 8″; Negley's Hill Park, Germantown, Phila. Co.

QUERCUS MONGOLICA GROSSESERRATA—Shallowcup Mongolian Oak
1′10″ at 8″; Morris Arboretum, Phila. Co.

This is an extremely picturesque, shrubby oak.

QUERCUS MONTANA—Chestnut Oak
4′ 5″; Friends Meeting, Lahaska, Bucks Co.

There are three other trees less than 4′.

QUERCUS NIGRA—Water Oak
1′ 0″; Residence of John Cadwalader, Norristown, Rd., Ambler, Montg. Co.

QUERCUS PALUSTRIS—Pin Oak
5′ 2″; 315 Orchard Way, Radnor, Del. Co.
5′ 0″; Residence of Bernhard W. Fox, Springhouse, Montg. Co.
4′11″; Sam Markley Farm, Burnside Ave., Norristown, R.D., Montg. Co.

QUERCUS PETRAEA MESPILIFOLIA—Medlar Durmast Oak
3′ 1″; Old St. David's Church, Newtown, Del. Co.

This is the Q. Sauli of Robinson (14); another tree stands nearby, and a third at Landover & Coopertown Rds., Bryn Mawr, Del. Co.

QUERCUS PHELLOS—Willow Oak
5′ 0″; Snipes' Farm and Nursery, Morrisville, Bucks Co.
4′10″: Haverford College, Del. Co.
4′ 3″; Oglethorpe Park Woods, Jenkintown, Montg. Co.

QUERCUS PRINUS (Michauxi)—Swamp Chestnut Oak or Basket Oak
4′ 5″; River Road, Upper Black Eddy, Bucks Co.
3′ 6″; Haverford College, Haverford, Del. Co.

QUERCUS ROBUR—English Oak
*4′ 5″ at 24″; St. Paul's Church, Chestnut Hill, Phila. Co.
4′ 2″; Van Sciver Estate, Chestnut Hill, Phila. Co.
3′10″; Harrison-Smith Foundation, Radnor, Del. Co.

QUERCUS ROBUR FASTIGIATA—Pyramidal English Oak
2′ 5″ at 24″; Breyer Estate, Elkins Park, Montg. Co.

This tree is in poor condition.

QUERCUS ROBUR PENDULA—Weeping English Oak
2′ 5″; Snipes' Farm and Nursery, Morrisville, Bucks Co.

QUERCUS X SAULI (White O. X Chestnut O.)—Saul Oak
*3′ 9″ at 30″; 1028 Easton Rd., Roslyn, Montg. Co.
A smaller tree is on the adjoining property.

QUERCUS STELLATA—Post Oak
3′ 4″; Tonner Estate, Grant and Milner Sts., N. Phila., Phila. Co.

QUERCUS VARIABILIS—Oriental Oak
1′ 5″; Morris Arboretum, Phila. Co.

QUERCUS VELUTINA—Black Oak
6′ 5″; Rte. 32, Yardley, Bucks Co.
5′10″; Garrett Tract, Edgmont, Del. Co.

ROBINIA PSEUDOACACIA—Black Locust
3′ 6″; Mattson Road, Concord, Del. Co.

SALIX BABYLONICA—Weeping Willow
4′11″; 32 Chester Pike, Glenolden, Del. Co.

SALIX BABYLONICA CRISPA—Crispleaf Weeping Willow
2′ 0″; 1 Franklin Ave., Erdenheim, Montg. Co.

Fig. 8. *Taxodium distichum*, the Bald Cypress, growing in the Tyler Arboretum. Note the distinctive "knees."

SASSAFRAS ALBIDUM—Common Sassafras
3′ 2″; Montgomery Country Day School, Old Gulph Rd., Penn Valley, Montg. Co.
3′ 0″; 3240 W. Schoolhouse Lane, Germantown, Phila. Co.

SEQUOIA SEMPERVIRENS—Coast Redwood
9″; The Barnes Foundation, Merion, Montg. Co.
The top of this tree has suffered from winter injury.

SEQUOIADENDRON GIGANTEUM—Sierra Redwood
3′ 2″; Tyler Arboretum, Middletown, Del. Co.

SOPHORA JAPONICA—Japanese Pagoda Tree
4′10″; Church of the Redeemer, Pennswood and Fisher Rds., Bryn Mawr, Montg. Co.
4′ 4″ at 30″; Tonner Estate, Grant and Milner, N. Phila., Phila. Co.
4′ 2″; 321 Rosemary Lane, Penn Valley, Montg. Co.

SOPHORA JAPONICA PENDULA
4″; 30 W. Bells Mill Rd., Chestnut Hill, Phila. Co.

STYRAX JAPONICA—Japanese Snowbell
2′ 1″ at 3″; 622 E. Gravers Lane, Wyndmoor, Montg. Co.
This is a fine tree.
Tree with 4 trunks, 10″-13″; Beaver College, Glenside, Montg. Co.

STYRAX OBASSIA—Fragrant Snowbell
1′ 6″ at 30″; Lankenau School, W. Schoolhouse Lane, Phila. Co.

SYRINGA AMURENSIS JAPONICA—Japanese Tree Lilac
1′10″ at 3″; 8211 Ardmore Ave., Wyndmoor, Montg. Co.

TAXODIUM ASCENDENS—Pond Cypress
*1′ 5″; Morris Arboretum, Phila. Co.
1′ 3″; Tyler Arboretum, Del. Co.

TAXODIUM DISTICHUM—Bald Cypress
4′ 1″; Longwood Gardens, Del. Co.
3′ 5″; Tyler Arboretum, Del. Co.

TAXUS BACCATA—English Yew
2′ 0″; Possibly largest in U.S., St. James Church, Bristol, Bucks Co.

TAXUS BACCATA FASTIGIATA—Irish Yew
3′ 1″; 948 Lincoln Ave., Springfield, Del. Co.

THUJA KORAIENSIS—Korean Arborvitae
1′11″ at 12″; Haverford College, Del. Co.

THUJA OCCIDENTALIS—Eastern Arborvitae
2′ 4″; Old St. David's Churchyard, Newtown, Del. Co.

TILIA AMERICANA—American Linden
*5′ 8″ at 18″; Mather's Mill property, Whitemarsh, Montg. Co.
4′10″; 822 Juniper Drive, Lafayette Hill, Montg. Co.

TILIA CORDATA—Littleleaf Linden
5′ 3″ at 18″; Awbury Arboretum, Germantown, Phila. Co.

This tree is a fine specimen with 7 trunks.

3′ 6″; 73 E. State Street, Doylestown, Bucks Co.

Ten or twelve fine younger trees are on the grounds of the Phila. College of Textiles and Science, W. Schoolhouse Lane, Phila. Co.

TILIA EUROPAEA—European Linden
5′ 7″ at 48″; 3240 W. Schoolhouse Lane, Germantown, Phila. Co.

TILIA HETEROPHYLLA—Beetree Linden
*4′ 1″; Morris Arboretum, Phila. Co.

TILIA PETIOLARIS—Silverpendent Linden
4′10″; 330 Spring Mill Rd., Villanova, Montg. Co.
4′ 5″; Swarthmore College, Del. Co.
4′ 4″; Alden Park, W. Schoolhouse Lane and Wissahickon Ave., Phila. Co.

All these Tilia petiolaris trees were grafted. There is some evidence they came from Hoopes Nursery in West Chester.

TILIA PLATYPHYLLOS LACINIATA—Cutleaf Linden
1′ 0″; Morris Arboretum, Phila. Co.

TILIA TOMENTOSA—Silver Linden
5′ 4″; 6012 Chew St., Germantown, Phila. Co.
5′ 1″ at 36″; Boy Scout Center, Elkins Park, Montg. Co.

Fig. 9. The magnificent *Ulmus parvifolia*, the Chinese Elm, near the pond in the Morris Arboretum.

TORREYA NUCIFERA—Japanese Torreya
1′10″ at 18″; Horticultural Hall Grounds, Fairmount Park, Phila. Co.
1′ 8″ at 24″; Swarthmore College, Del. Co.

TSUGA CANADENSIS—Canada Hemlock
4′ 2″ at 2′; Van Sciver Estate, Chestnut Hill, Phila. Co.

TSUGA CANADENSIS PENDULA—Sargent Weeping Hemlock
2′ 0″ at 12″; Tonner Estate, Grant and Milner, N. Phila., Phila. Co.

This is a clump of three, but the greatest spread of this one plant is about 40′.

1′ 7″; Morris Arboretum, Phila. Co.

TSUGA CAROLINIANA—Carolina Hemlock
1′ 6″ at 15″; Longwood Gardens, Del. Co.

TSUGA CHINENSIS—Chinese Hemlock
8″; Morris Arboretum, Phila. Co.

TSUGA DIVERSIFOLIA—Japanese Hemlock
1′10″; Morris Arboretum, Phila. Co.

TSUGA HETEROPHYLLA—Pacific Hemlock
20′ high; Morris Arboretum, Phila. Co.

TSUGA SIEBOLDI—Siebold Hemlock
1'10" at 6"; Morris Arboretum, Phila. Co.

ULMUS AMERICANA—American Elm
5'11"; St. Elizabeth Convent, Cornwells Heights, Bucks Co.
4' 5"; Springfield Friends Meeting, Del. Co.

ULMUS GLABRA—Scots Elm
4' 6"; Old Quaker Meeting, Marshallton, Chester Co.
4' 6"; Woodlands Cemetery, W. Phila., Phila. Co.
4' 4"; Haverford College, Del. Co.

ULMUS GLABRA CAMPERDOWNI—Camperdown Scots Elm
1' 7"; Morris Arboretum, Phila. Co.

ULMUS PARVIFOLIA—Chinese Elm
3'11" at 18"; Morris Arboretum, Phila. Co.
Six smaller trees of this beautiful species have been observed in the Phila. area.

ULMUS PROCERA—English Elm
4' 4"; Upper Darby Library, Upper Darby, Del. Co.

ULMUS PUMILA—Siberian Elm
4' 6"; Morris Arboretum, Phila. Co.

VIBURNUM PRUNIFOLIUM—Blackhaw Viburnum
*1'11"; Glen Mills Elementary School, Glen Mills, Del. Co.

ZELKOVA SERRATA—Japanese Zelkova
4' 8" at 18"; Ardmore Methodist Church, Argyle and Athens, Ardmore, Montg. Co.
This tree has seven trunks, a beautiful specimen.
2' 6" at 30"; Morris Arboretum, Phila. Co.

Literature Cited

1. American Joint Committee on Horticultural Nomenclature, Editorial Committee. 1942. Standardized Plant Names. J. Horace McFarland Co. Harrisburg, Pa. 675 pp.
2. Baxter, S. N. 1933. Notable Trees and Old Arboreta in and Around Philadelphia. Proc. Nat'l. Shade Tree Conf., 9: 23-31.
3. Fernald, Merritt Lyndon. 1950. Gray's Manual of Botany. 8th ed. American Book Co., N.Y. 1632 pp.
4. Littlecott, Lorna C. 1969. The Social Register of Big Trees. Amer. For. 75(2): 19-27, 46-48.
5. Martin, John Stuart. 1964. He Paints with Lakes and Wooded Slopes. American Heritage. 15(6): 14-18, 84-90.
6. McNeill, John T., Jr. 1966. Notable and Historic Trees of the Delaware Valley. Comstock Quarterly 13(3): 5-6; 13(4): 5-6.
7. ———. 1967. Notable and Historic Trees of the Delaware Valley. *ibid.* 14(1): 3-4.
8. ———. 1968. Great and Historic Trees of Philadelphia County. Germantown Crier. 20(1): 21-29.
9. Mickalitis, Albert B. 1969. Big Trees of Pennsylvania. Penna. For. Suppl. 59(3): 31 pp.
10. New Jersery Ext. Service. 1969. List of New Jersey's Biggest Trees. Leaflet 440. 6 pp.
11. Pomeroy, Kenneth B. and Lorna C. Littlecott. 1967. American Forestry Association's Social Register of Big Trees. 85 New Champs. Amer. For. 73(9): 28-33.
12. ———, and Dorothy Dixon. 1966. Social Register of Big Trees. The American For. Assn. Leaflet. 19 pp.
13. Rehder, Alfred. 1956. Manual of Cultivated Trees and Shrubs. 2nd ed. The MacMillan Co., N.Y. 996 pp.
14. Robinson, Mark. 1965. The Notable Trees of Delaware County, Pennsylvania. Proc. of the Del. Co. Inst. of Sci. 7(1): 2-21.
15. Swartley, John C. and Joseph L. Hayden, Jr. 1967. Some Trees Notable for Size and/or Rarity in the Philadelphia Area. Ed. Comm., Internatl. Shade Tree Conf. Leaflet for 43rd Ann. Conv. 16 pp.
16. ———. 1969. Some Trees Notable for Size and/or Rarity in the Philadelphia Area. Penna-Del. Chapt. 6, Internatl. Shade Tree Conf. Leaflet. 22 pp.
17. Wildman, Edward E. 1933. Penn's Woods 1682-1932. Philadelphia. Christopher Sower Co. 191 pp.

Peter Collinson F.R.S., F.A.S. 1694-1768

George W. Edwards

Peter Collinson was born on January 28th, 1694, in the City of London, England. His parents were members of the Society of Friends (Quakers) and Peter himself was a lifelong member. He early followed the advice of the founder of Quakerism, George Fox, who advised, "to study the nature of herbs, roots, plants and trees." As a boy, Collinson was keenly interested in all aspects of nature.

With his brother James, he conducted an extensive business as a woollen merchant from their business premises in Gracechurch Street, near to London Bridge; much of their trade was with the American Colonies.

He used to importune his overseas customers to send him seeds and plants, but what to an Englishman was rare and beautiful, was to the Colonist commonplace, and they soon tired of his demands. They could not be bothered. Eventually he was able to make arrangements with a John Bartram to undertake plant hunting expeditions and so secure what he wanted.

Bartram too was a Quaker and owned land near to the City of Philadelphia on the banks of the Schuylkill River. The house which he had built with his own hands is today the responsibility of the Fairmount Park Commission of Philadelphia. Much of the actual maintenance, decoration, and administration is by members of the John Bartram Association and one of the Garden Clubs of the Pennsylvania Federation.

Bartram had begun here the first botanic garden in the United States, which was soon enriched with trees and plants from England, for trade was by no means all one way. Collinson often sent to his American friends seeds which he had received from other European countries and from China.

In 1734, Collinson wrote to Mr. John Curtis of Williamsburg, thanking him for a present of a rare plant and added, "as a token of my gratitude to you I desire your acceptance of a box of Horse Chestnuts. Why this name is imposed on this noble tree I cann't say for no horse that ever I heard will eat the nuts or delights in its shade more than that of any other tree. Rows of these trees planted before your houses next the street at Williamsburgh would have a fine effect."

To make it more worthwhile to send consignments from America, Collinson obtained subscribers from among his Quaker friends and also from the British Aristocracy, among whom were the eighth Lord Petre, the second Duke of Richmond, the Dukes of Bedford and Norfolk, and also Lord Bute who supplied the Dowager Princess of Wales with plants for her Botanic Garden at Kew. Philip Miller, the Curator of the Apothecaries' Garden at Chelsea, was so keen a collector and so eager was he to secure new plants for his gardens, added to his ability to identify them, that he became one of Bartram's most important patrons, and also sent seeds and plants from Chelsea to Bartram.

A price of 5 guineas was agreed for a box of 100 different plants or seeds to be sent over, but this was soon increased to 10 guineas. From 1735 until his death in 1777, when his son took over the responsibility, John Bartram sent over annually seeds, trees and shrubs and sometimes small mammals to England.

Although Bartram and Collinson never met, a warm correspondence grew up between these two lovers of nature. "My dear John" and "my dear Peter" were the terms by which they addressed each other, showing the affection that they had for one another, fostered by their mutual interest in botany and also their common religious faith as Quakers.

While plants are the main interest, one of the early letters makes it clear that "every uncommon thing thou finds in any branch of nature will be acceptable." On one occasion, to Collinson's surprise and delight, as he was unpacking Turtles' eggs, they began emerging. He sat fascinated as the small creatures gradually released themselves.

In a letter to John Curtis, he complains of the poor treatment his plants received from certain sea captains. "Boling has acted a very unkind part both to you and me. I have never seen anything you sent me by him. The garden truck was carelessly put in the steerage where a dog tore all to bits. Boling's ship lay several days neigh me and he was in town but ever so kind as to call on me nor knew nothing of the matter till Mr. John Randolph told me they were all dead. I have been ill used and it has given me more uneasiness

Fig. 1. The portrait of Peter Collinson that hangs in Mill Hill School. According to Michael Hart, Headmaster, expert opinion attributes it to the "School of Gainsborough." Photo courtesy Mill Hill School.

than if I had lost 100 times the value in anything else." He advised Bartram to send the plants on one of his friend's ships, the captain of which would take better care of them.

Collinson could use a whimsical style to obtain more plants: "I have a sprig of Kalmia in water; it stares me in the face all the time I am writing seeming to say—'as you are so fond of me, tell my friend John Bartram who sent me to you to send more to keep me company, for they will be sure to be well treated'."

So indefatigable was Bartram, that within a few years Collinson had to ask him not to collect any more Tulip cones (*Liriodendron*), Swamp Laurel cones (*Magnolia virginiana*), Hickory, Black Walnut, Sassafras nor Dogwood, Sweet Gum, White Oak Acorns, Swamp Spanish Oak nor Red Cedar (*Juniperus virginiana*), berries. He asked him to send instead seeds of Firs, Pines, Black Gum and Black Haw Trees, Wild Roses, Black Beech and Hornbeam. In particular, Collinson wanted a locust known as Guelder Rose.

In the Herbarium at the Natural History Museum at South Kensington, London, are lists, written in Collinson's own hand, of the seeds contained in each box received from Bartram, shipped during 40 years.

Collinson's business was in the Parish of St. Benet, Gracechurch Street. Quakers generally refused to serve as Churchwardens, but both Peter and his brother felt able to serve that office, and to remain as Vestrymen, among whose duties was the care of the parish poor. The Churchwarden's minutes for 1759 record: "Peter Collinson, James Collinson, Mercers and Haberdashers, lived at the sign of the Red Lion, being the first house in the parish on the west side from Fish Street Hill, have served this parish above 50 years."

Fish Street Hill leads to the Pool of London, so he was able to visit ships bringing the various consignments and to obtain clearance through Customs and to distribute quickly to the subscribers.

Not only were the plants at hazard during long sea voyages, but "villains," as Collinson describes them, often robbed him of many species, taking from his garden his more rare and beautiful plants roughly tearing them from their beds. "The loss of so many fine plants affects me more than the loss of Pitt," he wrote to a friend. After these losses he would send a list to Bartram and ask him to supply replacements.

Collinson obtained the appointment of Botanist to the King for Bartram in April, 1765. Great was his joy when he could write to his friends: "I have pleasure to inform my good friend that this day I received intelligence from Our Gracious King that he had appointed thee as his Botanist with a salary of £50 a year. Now dear John thy wishes are to a degree accomplished to range over Georgia and Florida." He also has to remind Bartram that he is wearing a chain that has only 50 links, and not to go any further than his allowance permits.

In 1728, Collinson was elected a Fellow of the Royal Society and from 1732 served on the Council. He was one of the original Fellows of the re-organised Society of Antiquaries, and was also elected to the Royal Societies of Berlin and Sweden.

Benjamin Franklin was another of Collinson's friends in the New World and Franklin always brought some new plant for Collinson whenever he visited England. Franklin was at one time experimenting with electricity. He began these experiments using a piece of apparatus sent to him from England by Collinson. Later when Franklin was nominated for election as a Fellow of the Royal Society, Collinson signed the nomination papers and was the first to notify Franklin of his election.

Collinson was the agent in London for the Philadelphia Library, established by Franklin, and sometimes he shipped goods economically to Bartram under care of the library. In 1742 he writes: "In the trunks of the library thee'll find a suit of clothes for thyself. This may serve to protect thy outward man being a drugget coat, black waistcoat, and shaggy breaches."

Collinson supplied Sir Hans Sloane with many specimens for his vast collection of stones, crystals and curios. Sloane's collection formed the nucleus of the British Museum and when it was first displayed to the public at Bloomsbury it was Collinson who arranged the Natural History section.

The London Quaker, Doctor Fothergill, frequently used quinine in his treatment for influenza; it was Collinson who had brought it to his notice. Writing to the Swedish botanist, Linnaeus, Fothergill said: "Our Collinson taught me to love flowers and who that shared his comradeship could do other than cultivate plants." When in England, Linnaeus visited Collinson's garden and often Collinson would send him plants to be named. In the spring of 1767, Collinson described his garden to Linnaeus:

"February brought soft sunny days and continued mild and warm, with southerly winds all the month. This brought on the spring flowers. By February 8 the Hellboris Niger made a fine show. The Galanthus and Winter Aconite by the 15th covered the garden with beauty, with more than 20 different species of Crocus, produced from seed, and with Iris Persica,

Cyclamen vernalis and Polyanthus. By the 16th March, plenty of Hyacinthus Coeruleus and Albus and in the open borders with Anemonies and my favourites, Narcissus, show all over the border. The Tulip Praeon is near blooming."

When Peter Kalm was in England in 1748, he wrote: I went to Peckham, a pretty village, where Peter Collinson has a beautiful little garden full of all kinds of the rarest plants, especially American ones. There is scarcely another garden where so many trees and plants are to be found."

The following year, Collinson inherited from his wife's family, an estate at Mill Hill, 14 miles north of London, where he lived until his death. It took him two years to transplant there his collection from Peckham. Forty years after Collinson's death, the property at Mill Hill was acquired as a school which still continues on the site. One of the houses is named Collinson House and his portrait hangs in the Headmaster's Study. Trees from Collinson's time—Cedars, Oriental Plane and a Swamp Cypress among them—still flourish in the grounds and the School Governors continue new plantings as Peter would have wished.

Many of Collinson's trees still flourish in the parks of large houses. Both the second and third Dukes of Richmond were enthusiastic gardeners and Collinson was their guest on a number of occasions, advising on the landscaping of their estates.

The second Duke of Richmond had purchased Magnolia seeds from the first consignment sent over in 1743. Bartram had discovered them near the Great Lakes. During a visit in 1759, Collinson found these Magnolias had made considerable growth. Today they still flourish and cover the walls of the house.

For the third Duke, Collinson supplied 1,000 Cedars at a cost of £79. 6. 0. Some 80 of these magnificent trees are now the glory of the Goodwood Estate.

Collinson waxed eloquent when writing to Bartram about another of his patrons, Lord Petre, who had been the first subscriber to Bartram's boxes. Ten thousand American, twenty thousand European and many Asian trees had been planted at Thornton by Petre who had studied the growth of each variety. He had blended the shades of colour, dark green against bluish green, with a shading of yellow, in thickets and clumps, with flowering shrubs filling the outskirts of the borders. He kept his nurseries stocked in order to refurbish his plantations.

In his commonplace book, Collinson compares a gardener to an artist. Here he shows his deep understanding of nature and reveals his own loving personality. He writes:

"Everyone that could beautifully imitate nature should well consider the diversity and growth of trees, the size and shape of leaves, and the many shades of green. To know how properly to mix them in planting is another form of painting with living pencils. For greens properly disposed throw in a mixture and contrasts of lights and shades, which wonderfully enliven the picture and which insensibly strikes the senses with wonder and delight."

The list of plants that Collinson grew in his garden is very impressive. Many of them came from North America, but some also were sent from Russia and China and flowered for the first time in England in his garden. There was *Collinsonia*, yellow-flowered Labiate, named by Linnaeus. The Tree of Heaven, *Ailanthus altissima*, was raised by Collinson from seed sent by Father D'Incarville from China, *Kalmia latifolia*, which flowered for Collinson in 1746, and *Monarda didyma* were among the plants collected and sent by John Bartram. Magnolias were another special feature of his garden, and included *M. acuminata* and *M. tripetala*, which he introduced into England. He also introduced several species of Rhododendron, Phlox and Lilies. He was the first to grow *Lilium superbum*, *Cimicifuga racemosa*, white Cedar (*Chamaecyparis thyoides*) and Black Larch (*Larix pendula*).

Collinson died on August 11th 1768. He would have been particularly happy to have known that the Quaker Burial Ground in Bermondsey, South London, where his body lies, would one day become a children's playground. In spring, summer and autumn, its borders are gay with flowers and shrubs, some of which may have been grown by him for the first time in England.

Arboretum Activities

(Continued from Page 22)

The numerous cultivars of azalea in the "Azalea Meadow" are currently providing a highly colorful display. In addition, the floor of our oak-ivy lane has been brightened by hundreds of daffodils which were planted late last Autumn, a generous gift from an anonymous donor.

Showing little or no winter-damage were our specimens of the botanically interesting "Anise-Tree" (*Illicium floridanum* Ellis). It flowered freely in mid-May presenting a striking effect with its nodding, many-petaled flowers of rich maroon red coloration.

The plants made available for our local Associates on this year's Plant Distribution Days included the very rare *Conradina verticillata* Jennison (Family Labiatae) and the choice cultivars of Hybrid Holly, *Ilex* cv. 'John T. Morris' and 'Lydia T. Morris.'

As was the case last year, the Morris Arboretum was pleased to contribute a modest set of plants for the booth of The Historical Society of Pennsylvania at the Rittenhouse Square Flower Market on May 20 and 21.

THE STAFF

Dr. H. L. Li visited the Botanical Museum of Harvard University, April 16-17, in connection with organizing the laboratory materials for a new course on "Plants and Human Culture" which is to be offered in the Department of Biology beginning in the Fall Semester, 1970. In the first issue of the 1970 volume of the periodical *Economic Botany*, Dr. Li published the lead article entitled "Origin of cultivated plants in Southeast Asia."

In addition to her laboratory research, teaching, and editorial work, the Spring found *Dr. Allison* busy answering telephone inquiries, examining plant specimens brought in by Associates of the Arboretum, and visiting their gardens to diagnose troubles.

One of *Mr. Heeps'* extra springtime duties was the supervision of ground preparation for the Pennsylvania Horticultural Society's Garden Workshop for children.

Mr. Keyser, through the generosity of one of the Arboretum Associates, was able to attend the annual meeting of The American Rhododendron Society in Vancouver, B.C.

Dr. Dahl presented a lecture entitled "Pollen in Space" before the Faculty Women's Club of the Penn Wynne Library on April 7, 1970.

A. Orville Dahl

About Our Authors

John C. Swartley, Ph.D. The Ohio State University, was chairman of the Horticulture Department of Temple University, Ambler Campus, for several years before his retirement in 1967. In addition to his academic activities, he has for many years been an active member of professional societies as well as a landscape consultant and contractor. Figure 4 of his article is by Phillip Ruess of Ardmore; figure 8 is published through the courtesy of the Tyler Arboretum; the cover photographs and all others were made by Frank Casino, Ambler.

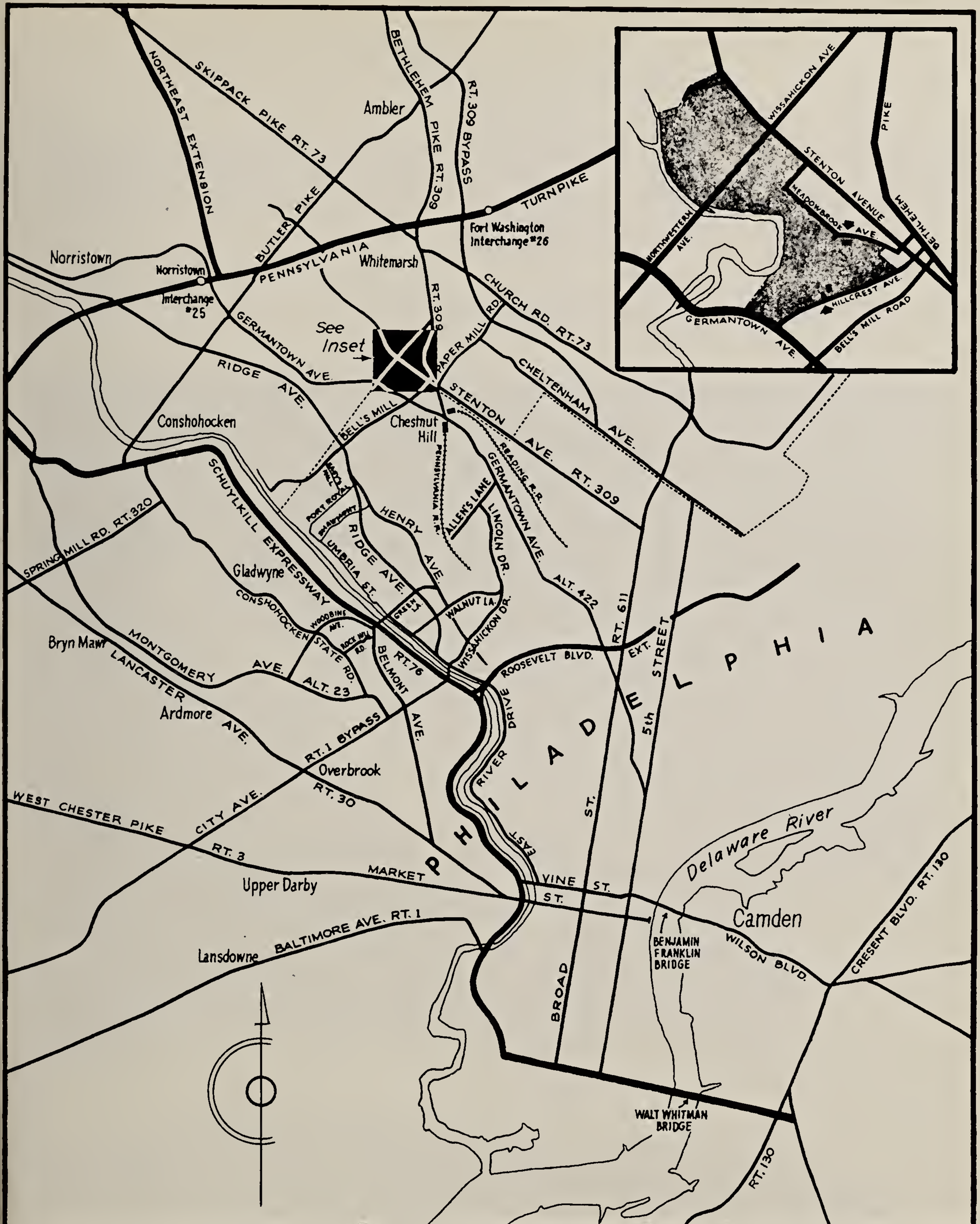
As may have been detected in the style with which his subject was treated, *George W. Edwards* seems almost to have achieved a personal friendship with Peter Collinson even though more than two centuries intervene.

He writes of Collinson, "He must have been a really lovable person; he was a kindly soul, going out of his way to help others, whenever it was in his power, with whatever they were interested in." Their lives are strangely interwined: On the one hand, Mr. Edwards, himself a member of the Central Library Committee of the Society of Friends, has for 40 years been also a Trustee of a certain old Quaker Burial Ground, familiar to him from the days he spent playing there as a child. Mr. Edwards has maintained a keen interest in the history of London. He has even constructed accurately detailed miniatures of famous buildings of old London, complete with tiny passers-by garbed according to the time. So authoritative is his knowledge of historical London that it qualified him to become one of the first "Registered London Guides."

On the other hand, Mrs. Edwards was an enthusiastic horticulturist who became interested in the activities of Peter Collinson. Together, she and Mr. Edwards discovered that Peter Collinson was buried in the selfsame Burial Ground in which our author had played.

But there is yet another coincidence. Recently, the American Philosophical Society published a splendid volume by Joseph Ewan about William Bartram, son of John. In it are discussions of Collinson's relationships with the Bartrams and the helpful way he circulated William's drawings and paintings among important naturalists of 18th century England. One of these men was Dr. Fothergill whose collection, now in the British Museum (Natural History), is illustrated in Professor Ewan's book. Another of the early naturalists was named George Edwards.

While on a lecture tour in the United States, the modern Mr. Edwards visited Bartram's Garden. It is our hope that he will one day visit the Morris Arboretum.



MAP SHOWING ACCESS TO THE MORRIS ARBORETUM, PHILADELPHIA, PA.

Morris Arboretum Bulletin

LEGES SINE MORIBUS VANAE

Vol. 21 SEPTEMBER, 1970 Number 3

The leaf-like body and wings of this tropical mantid deceive its meat eating predators.

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Sponsoring	$100.00 a year
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About Our Authors

Michael H. Robinson, Ph. D., Oxford University, is a research biologist at the Smithsonian Tropical Research Institute in the Panama Canal Zone, and also a member of the Graduate Group in Biology at the University of Pennsylvania. His main interest is the study of evolution. Working with the adaptations associated with predator-prey relationships has proved most fruitful. He is especially interested in mammalian predators. All of the illustrations except Figure 4 are from his photographs. Figure 4, the remarkable photograph of the flower-mimicking spider, is from a color transparency made by University of Pennsylvania colleague, Dr. R. E. Rickleffs.

Frank S. Santamour, Jr., Ph. D., Minnesota, formerly Geneticist at the Morris Arboretum, is now Research Geneticist at the National Arboretum where he has been continuing his cytological investigations of *Magnolia* spp. The National Arboretum is part of the Crop Research Division, Agriculture Research Service, U.S. Department of Agriculture, Washington, D.C. 20002.

(Continued on page 65)

Animals That Mimic Parts of Plants

Michael H. Robinson

Every biologist knows that plants are the ultimate source of food for all animals. A huge assemblage of animals feed directly on parts of plants, living and dead, and still other animals feed on these primary consumers; however, few, if any, of the predators ever mix their diets by feeding on plant material. This is, undoubtedly, the explanation of why a wide variety of animals have evolved structures, and behaviors, which allow them to mimic parts of plants. It is a device which puts them outside the range of the predator's diet. Most people are familiar with the walking sticks and stick caterpillars of the temperate regions, but it is in the tropics, where predation pressures may be more complex and food chains more diverse, that the most specialized "vegetable disguises," as Alfred Russel Wallace called them (1), are found. In this paper I will describe some of the adaptations to plant mimicry that I have seen, and studied, in the Neotropics and Ceylon. These adaptations are not only interesting in themselves, but lead us to ask a number of wide-ranging questions of considerable biological interest.

In essence, an animal which is responding (in evolutionary time) to the presence of visually hunting predators by adopting some visually operating protective mechanism may do so in one of three ways. It may signal its real inedibility or obnoxiousness to the predator by way of its conspicuous coloration and bold patterning. This is the mechanism of *aposematism* or warning coloration. The animals of this kind include many of the familiar yellow and black, and red and black, insects, spiders and snakes. The colors that are involved in aposematism are those which are most conspicuous to the eyes of many vertebrate predators. In addition, the bold patterns facilitate learning of the association between the color pattern and inedibility; their convergent use by a broad spectrum of distasteful animals (Müllerian mimicry) may further facilitate avoidance learning.

The second type of visually operating protective mechanism depends on the animal's signalling *false* information about its inedibility, or obnoxiousness, to the predator. Here there are several possible strategies. The animal may mimic a distasteful model by having false warning coloration (*pseudaposematism*). This is the case with Batesian mimics. On the other hand, it may mimic a generally dangerous group of animals such as snakes. Thus a large number of Hawk Moth caterpillars (Sphingidae) have displays involving snake mimicry. Finally, in this second category, the animal may mimic parts of plants such as leaves, sticks, and flowers, which are normally inedible to predators. This is our subject.

The third major defensive strategy is to suppress signals that could reveal the potential prey item to the predator. This is the technique of camouflage, in the strict sense. Camouflage may result from matching the color of the background on which the animal rests, from outline obliteration (by countershading and obliterative patterning), or from the concealment of otherwise conspicuous features such as eyes, legs, and heads. The animal may thus suppress the attention-eliciting visual cues of shape, solidity, and characteristic structure. Any or all of the camouflage devices listed above may occur in one animal. Their effectiveness as a means of defense has been demonstrated in a number of experimental studies (2, 3, 4).

We can ask whether there is really any distinction between plant-part mimicry and camouflage (as defined above). This, in turn, may be part of another question. The number of animals that have exploited plant mimicry is small in relation to those with camouflage devices. In addition, the morphological specializations involved in plant-part mimicry are more extreme and costly, in terms of energy investment, than those involved in camouflage. Is there then some advantage to stick- and leaf-mimicry that is not possessed by the camouflage strategy? One answer to this question may be that successful camouflage is inevitably dependent on the animal's resting on the appropriate background (i.e., one which matches its own coloration) whereas the plant-part mimic may be protected regardless of the background. A camouflaged animal on the inappropriate background may be very conspicuous whereas a stick mimic may be confused with an inedible stick wherever it rests. There is good experimental evidence that the camouflage system is background dependent. Kettlewell (2), for instance, was able to show that melanistic (black or very dark) moths were protected only by their camouflage when resting on the soot-blackened tree trunks of some English forests. They were unprotected on clean trees. Selection for the black moths is assumed to have taken place after the occurrence of massive atmospheric pollution. On

Fig. 1. Immature male walking stick *Pterinoxylus spinulosus* (Redtenbacher) in typical mimetic posture; length, ca. 108 mm. Note the complex attitudes of the legs.

the other hand, I have been able to show that stick insects are protected from the sharp eyes of small monkeys even when they are presented on a contrasting background (5). This may be one important advantage of plant-part mimicry—the animal is protected in a greater variety of situations if it resembles the inedible. Of course, some camouflaged animals may actively change their colors to match a variety of backgrounds but this is probably a complex and restricted adaptation.

Examples of Plant-part Mimicry

Forms of plant-part mimicry are restricted to a relatively small number of animal groups. In terrestrial animals, by far the most perfect examples occur in the Arthropoda, and, within this phylum, the insects and the spiders show the most complex specializations. In insects, plant mimicry occurs in at least five orders. These are: the Dictyoptera (mantids), the Phasmatodea (walking sticks and leaf insects), the Orthoptera (grasshoppers and katydids), Hemiptera (thread-legged bugs), and the Lepidoptera (stick caterpillars and leaf-like butterflies and moths). In spiders, plant-part mimicry occurs mainly in the web-builders. Of the insects, the phasmids (Phasmatodea) are the group with the greatest number of species of plant-part mimics. The Orthoptera come second with several convergent stick-like species, a whole family of stick mimics restricted to the New World (the Proscopidae), and a large number of leaf-mimics (mainly in the family Pseudophyllidae). In the case of the mantids, there are stick- and leaf-mimics from all the tropical regions.

In all cases, plant-part mimicry is achieved by a *combination of morphological and behavioral characters*. The behavioral aspects of this form of defense have been underemphasized in the past, mainly because very few scientists have made detailed observations of the living animals in their natural surroundings. Such observations add greatly to our knowledge of the incredibly intricate nature of some of these defensive adaptations. Behavior contributes to plant-part mimicry largely through the adoption of highly specialized postures. I have called these postures *mimetic attitudes* (6) because they are not, in all cases, assumed by the resting attitude and may occur only in response to the presence or proximity of a potential predator. This is true of the diurnally active mantids, but most plant-part mimics are nocturnally active and *do* by day adopt immobile mimetic attitudes. Figure 1 shows a walking stick from Panama in a particularly interesting mimetic attitude. If this photograph is examined carefully one can see that the posture involves complex attitudes of all the insect's six legs. The anterior legs are held in a position which is typical of many stick-mimics: they project, side by side, in line with the long axis of the body. In this attitude they surround and conceal the antennae and head (upper right). They also increase the apparent length of the insect and thereby enhance its stick-like appearance. In addition, the intermediate (middle pair) legs are held in an even more complex attitude. Note that they do not touch the substrate, but project upwards in two discrete twig-like positions. Their jointed structure is concealed by the fact that they are folded back upon themselves and the opposing edges of the leg elements (femur and tibia) fit tightly together so that the whole structure appears to be homogeneous. Folds and projections on the opposing edges of the leg joints also help to mask the separate elements. The hind legs project underneath (ventrally) at an oblique angle, and once again the tibia is apposed to the underside of the femur, producing an apparently homogeneous structure. The total effect is that of a stick with side branches and not of a stick with legs.

A similar effect is produced, by an altogether different posture, in the mimetic attitude of the tettigoniid shown in Figure 2. Here the insect mimics a dead leaf—even to the extent of having false fungi on its dark brown fore wings. These comprise the "leaf" and are complete with a distinct mid-vein; they also cover the segmented abdomen. Once again the legs, which might otherwise be a give-away clue to predators, are held in complex attitudes. The long hind legs (used in jumping) are not only very twig-like and woody in appearance, with clearly visible lenticel-like markings, but are also held in stiffly out-

Fig. 2. A leaf-mimicking tettigoniid *Mimetica mortuifolia* Pictet, adult female; the head is facing to the right of the picture; length, ca. 50 mm.

stretched postures. The smaller anterior and intermediate legs are folded against each other and their separate structure is concealed. At the same time, these legs are able to grasp the twig on which the insect rests.

The stick-like spider shown in Figure 3 has been disturbed, and has abandoned its mimetic attitude. It is thus recognizably, at least by counting its legs, a spider. In the mimetic attitude the legs are all held in attitudes that conceal their structure and also increase the apparent length of the body. The first and second pairs of legs are held together in front of the body and the other legs are held against the sides of the abdomen. Careful examination of Figure 3 will reveal a line of silk attached to the opening of the silk glands near the base of the abdomen (at the waist). In spiders that are not so remarkably elongate as this stick-mimic, the silk glands open near the apex of the abdomen.

An even more remarkable form of plant-part mimicry is shown by the spider illustrated in Figure 4. I collected this spider in the tropical rain forest of Barro Colorado Island and brought it back to the laboratory to make behavioral observations. There it unfortunately escaped, so that it remains unidentified, and was the only one seen during three years of collecting. In life it was remarkably like the tubular flower of a jungle tree, fallen from the canopy and caught in a spider's web. As can be seen from the photograph, its elongate abdomen hangs below a horizontal silk support and is totally unspiderlike in profile. (The silk is not visible.) The specimen was beautifully colored, combining pale yellow and lilac. Once again the legs are held in inconspicuous attitudes and do not disrupt the overall flower mimicry. We do not know whether the mimicry is directed against the spider's insect prey or against its own predators. If we had been able to test the appearance of the spider when viewed through an ultra-violet filter this problem could, possibly, have been resolved. If it were to have a conspicuous appearance in the ultra-violet, this would have been suggestive of coloration directed against vertebrate predators rather than insects (since many insects are highly sensitive to ultra-violet wavelengths). If in the ultra-violet it resembled similar flowers, we might conclude that its mimicry was aggressive—directed against flower-visiting insects and thus acting as a lure.

Figure 5 shows another form of plant-part mimicry seen in a walking stick from the very wet forests of Panama. Here, where the trees are laden with epiphytes of many kinds, the insect has complex "mossy" or lichenose projections from almost every part of the body and legs. These are elements of the insect's structure and not epizooites. Some insects actually grow mosses and lichens on their body surfaces and achieve a similar effect (7). This walking stick did not assume a complex mimetic attitude and this may be correlated with the fact that the typical insect structures are concealed by their specialized outgrowths. Notice that even the antennae are held in curly tendril-like attitudes.

Fig. 3. The stick-mimicking spider *Argyroides* sp., length, ca. 30 mm.

Figure 6 shows a leaf-mimicking mantid. In this insect, the normally thin and rod-like prothorax (first body segment) is in the form of a flattened green shield. This completely conceals the anterior (prey-

catching) legs from above. When the insect is not flying the tough green fore wings conceal the membranous hind wings and the total insect is very leaf-like. In Ceylon a similarly shaped mantid combines a dorsal dead-leaf mimicry with a brightly colored and flower-like ventral coloration.

Fig. 4. Unidentified flower-mimicking spider, length, ca. 20 mm. (photo, R. E. Ricklefs)

This selection of examples of complex adaptations could be greatly extended, but it seems worthwhile to use them to formulate some questions and also to propose some answers to these questions. We can ask, for instance, how these adaptations could have evolved. Such a question can be approached at several levels. We can look for stages that, possessing survival value in themselves, could have been stepping stones towards forms of stick- and leaf-mimicry. We can also examine the question of whether such adaptations are too perfect, whether detailed mimicry is really called for as a response to the discriminatory powers of predators. The first part of the evolutionary problem is to suggest a function for the behavioral and morphological specializations involved in stick- and leaf-mimicry before they reach their present stage of development. It seems inconceivable that all the adaptations could arise *de novo* in one step.

Evolution

Clues about the possible steps in the evolution of some types of stick- and leaf-mimicry can be derived from comparative studies of related mimetic and non-mimetic forms. In the primitive family of walking sticks, the Pseudophasmini, I have found a number of forms with different resting attitudes. Some relatively short walking sticks assume prostrate resting attitudes and these are very revealing cases. The insects do not assume angled stick-like attitudes from their resting substrates. In fact they rest with the lower surface of their body pressed against a twig or branch. The insects that do this are best regarded as camouflaged, and match their background coloration. Figure 7 shows a katydid in a prostrate resting position on a tree trunk. A similar sort of resting attitude is found in walking sticks belonging to the genera *Metriotes*, *Prisopus* and *Acanthometriotes* (8). It is also found in the immature stages of some stick insects that are true stick-mimics as adults (8, 9). Most of the insects which adopt prostrate resting attitudes are flattened, or concave, on their undersurface where they rest against the substrate. In addition, they may be generally flattened (*Prisopus* sp.) or partially elongate. In insects that adopt a camouflaged prostrate attitude, there would be advantages to any steps towards elongation or lateral flattening. Both elongation and lateral flattening would enhance profile concealment. Elongation would perhaps contribute most to the concealment of insects that rested on elongate, but curved, parts of plants—on twigs and leaf veins. Lateral flattening would be most advantageous to insects resting on flat or slightly curved surfaces such as tree trunks and broad leaves. Each step in elongation is a potential pre-adaptation to stick-mimicry and each step in flattening a step towards leaf-mimicry. The complex

Fig. 5. The "mossy" walking stick *Trychopeplus laciniatus* (Westwood), adult female; length, ca. 97 mm. (From Robinson, 1970a, by permission of Royal Entomological Society of London.)

leg attitudes of the true plant part mimics are partially foreshadowed in the prostrate, resting walking sticks and katydids. Thus the insect shown in Figure 7 holds the anterior legs together and in line with its long axis as do the walking sticks of the walking stick genera mentioned above. These leg attitudes would be adaptive in non-mimics if they contributed to a smooth anterior profile (enhancing concealment) and also helped to conceal the structure of the legs, head, and antennae (suppressing signals that might be a give-away to a predator). They may also be a solution to the mechanical problem of resting on sticks. With increasing elongation, and the addition of leg-concealment postures, the steps to stick mimicry are not great.

Having thought of this possible pathway to stick-mimicry (by way of prostrate camouflage attitudes) I was very excited to discover that another walking stick from Panama, a species of *Isagoras*, possessed a resting attitude intermediate between the prostrate resters and the typical stick insects. This insect rested with its thorax and anterior legs appressed to the substrate and its abdomen projecting upwards at an angle. That the free projection of the abdomen was not fortuitous was suggested by the fact that the dark dorsal coloration of the abdomen extended onto its ventral surface. The lower surface of the thorax, normally concealed as it is pressed against the substrate, was pale and sparsely pigmented.

To summarize, it seems possible that increasing elongation could be adaptive as a means of predator avoidance by simple concealment, and then have reached the stage from which the steps to stick-mimicry were possible. Similarly the enhancement of concealment by flattening could have been the starting point for evolution towards leaf-mimicry. This scheme is, of course, mainly applicable to the evolution of stick- and leaf-mimicry in the phasmids. There are no clues, as yet, about how the mantid stick- and leaf-mimics could have evolved. In butterflies and moths, leaf mimicry is achieved by the shape and patterning of the wings. Here the steps from simple camouflage to leaf-mimicry may be fairly simple. The resting outline of a moth may be crudely leaf-like without any specialization, and Turner (3) has shown that birds may be fooled by a crude imitation of a leaf. In the same way, the step from an already elongate caterpillar to a stick caterpillar is not too difficult to envisage.

The above speculations are all founded on the belief that visually hunting predators are important selective agents and that they may respond to fine details of the structure of their prey. There is some experimental evidence on the latter point. Although some predators may respond primarily to moving prey, as is the case with many frogs and toads, others are known to be capable of responding to motionless, cryptic prey. De Ruiter (10), who studied the responses of European Jays to stick caterpillars, obtained some very interesting results. These birds proved capable of distinguishing between caterpillars and sticks on the basis of very slight differences in appearance. The same worker also showed that the

Fig. 6. The leaf-mimicking mantid *Choeradodis rhombicollis* (Latreille), adult female; length, ca. 71 mm.

Fig. 7. Adult male tettigoniid *Acanthodis curvidens* (Stål), length, ca. 95 mm.

Jays were capable of finding countershaded caterpillars if these were oriented the "wrong" way in normal lighting. The caterpillars are marked in such a way that the form-delimiting effects of shadows and highlights are cancelled out by appropriate bands of light and dark coloration. An incorrectly oriented caterpillar was more conspicuous to the Jays than the caterpillar in its normal position and suffered higher predation. My own experiments on the responses of small tropical monkeys to insects show that these keen-sighted predators can find walking sticks very rapidly if the insect has its legs in non-mimetic attitudes (8). For the insect to have only one pair of legs extended enhances greatly the chance that it will be found and eaten. From what little we know about the discriminatory powers of predators, it is reasonable to suppose that selection on prey animals will act towards the perfection of visually operating protective devices.

Other Lines of Defense

Many plant part mimics have other lines of defense that are brought into play if their mimicry fails to deceive the predator. The walking stick shown in Figure 1 has brightly colored wings that are erected suddenly if the insect is pinched or prodded. The sudden increase in size that is effected by wing erection may startle the predator and permit escape. Other stick and leaf mimics run, jump, and fly when disturbed and still others spray out noxious chemical secretions. The existence of these second lines of defense suggests that there are predators which are not fooled all of the time. In addition, the plant part mimics may move from place to place during the day in a most peculiar manner. The stick-like mantids and walking sticks rock from side to side as they walk, and leaf mimics make side-to-side fluttering movements. These movements are similar to those of sticks and leaves passively moved in the wind. It seems possible that predators learn not to respond to the irrelevant natural motion of twigs and leaves and that, as a consequence, they may also be unresponsive to stick- and leaf-like insects moving in the same way. For technical reasons, this is an extremely difficult hypothesis to test experimentally. I have been able to show that forest-dwelling monkeys do not overtly attend to twig and leaf movements but will fixate twigs and leaves moved in an unnatural "animal" manner. At a more general level, I have been able to show that domestic chicks can learn to peck at some types of movement whilst learning not to peck at others. This is a very limited start towards finding out whether plant part mimics could gain protection by not only looking like parts of plants but also by *moving* like parts of plants.

Other Problems

There are still a number of problems concerning plant part mimicry for which we have no answer at present. One of these concerns the apparent rarity of such mimics. In any particular habitat, there always seem to be far fewer stick and leaf mimics (both in numbers and numbers of species) than there are insects possessing simple camouflage devices. This apparent rarity may simply be a reflection of the success of this form of visual defense, there may simply appear to be fewer plant part mimics because we cannot see the stick insects for the sticks. For a variety of reasons it seems reasonable to assume that the apparent scarcity may reflect a real scarcity. How can this be explained? At first sight a complex

adaptation would seem to confer a selective advantage only if it were successful in contributing to the survival of more individuals than the less complex forms. This is false logic in the sense that both the presently complex stick-mimics and the superficially less complex camouflaged insects may have survival advantages over their (presumably) more generalized ancestors. They may simply have achieved different solutions to the problem of defense against predators. Perhaps the plant part mimics have a maximum investment in visual defense, whereas the camouflaged animals have part of that investment in other forms of defense.

Problems will remain until we know a great deal more about the total biology of whole organisms. The field is immense and stimulating.

References

1. Alfred Russel Wallace. 1897. Tropical Nature.
2. Kettlewell, H. B. D. 1955. Selection experiments on industrial melanism in the Lepidoptera. Heredity, Lond. 9: 323-342.
   ______. 1956. Further selection experiments on industrial melanism in the Lepidoptera. Heredity, Lond. 10:287-301.
3. Turner, E. R. A. 1961. Survival values of different methods of camouflage as shown in a model population. Proc. Zool. Soc. Lond. 136: 273-284.
4. Popham, E. J. 1941. The variation in the colour of certain species of *Arctocorisa* (Hemiptera, Corixidae) and its significance. Proc. Zool. Soc. Lond. 111: 135-172.
5. Robinson, M. H. 1969. Insect anti-predator adaptations and the behavior of predatory primates. Actas del IV Congresso Latinamericano de Zoologia, Caracas.
6. ______. 1969. Defenses against visually hunting predators. *In* Dobzhansky, Th., M. K. Hecht, and W. C. Steere, (Eds), Evolutionary Biology III.
7. Gressitt, J. L. 1969. Epizoic symbiosis. Entomological News. 80: 1-5.
8. Robinson, M. H. 1970a. In press. The defensive behaviour of some orthopteroid insects from Panama. Trans. R. Ent. Soc. Lond.
9. ______. 1970b. The defensive behaviour of the stick insect *Oncotophasma martini* (Griffini) (Orthoptera: Phasmatidae). Proc. R. Ent. Soc. Lond. (A) 43: 183-187.
10. Ruiter, L. de. 1952. Some experiments on the camouflage of stick caterpillars. Behaviour. 4: 222-232.

Cytology of Magnolia Hybrids. II.

M. x *soulangiana* Hybrids.

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The first paper (Santamour, 1969) in this extended study of cytology in *Magnolia* hybrids was devoted to hybrids between species belonging to different sections of the genus. The plants discussed below are also intersectional hybrids, but they have been treated separately because of their special characteristics among cultivated magnolias.

By far, the greatest number of named cultivars in the genus *Magnolia* belong to an assemblage of hybrids designated as *M.* x *soulangiana* Soul.. This hybrid series originated from a natural cross between *M. denudata* Desr. (section Yulania) and *M. liliflora* Desr. ex Lam. (section Tulipastrum). The original *M.* x *soulangiana* was raised by Chevalier Soulange-Bodin in his garden at Fromont, near Paris, in 1820. Although this hybrid combination may be quite sterile, there is sufficient fertility to allow for the numerous second (and later) generation hybrids and probably backcrosses to parental types that have been selected from seedling populations since that time.

The first cytological examination of the *soulangiana* group was made by Whitaker (1933). He reported that three plants of *M.* x *soulangiana*, 'Brozzonii', 'Candolleana', and an unnamed cultivar, were tetraploids with a meiotic chromosome number of n=38. Since he also found that *M. liliflora* was tetraploid, he thought it probable that the other parent, *M. denudata*, was likewise n=38. His drawing of first metaphase in 'Brozzonii' shows 38 bivalents. He noted an average of 25 per cent pollen sterility in the *soulangiana* cultivars, as compared with only 7 per cent in the parent species *M. denudata* and *M. liliflora*.

Janaki Ammal (1953) reported that *M. denudata* was a hexaploid (2n=114), and thus the hybrid *soulangiana* ("several varieties") was a pentaploid with 2n=95 chromosomes. She also stated (perhaps in reference to Whitaker's work), "there are also tetraploid *M. soulangiana* that resemble *M. liliflora* so closely that they cannot be distinguished from it." The one cultivar of the *soulangiana* group designated by name was 'Lenneana' (='Lennei'), which she reported as a hexaploid with 2n=114 chromosomes.

Fig. 1. Meiotic chromosome configurations in *Magnolia* x *soulangiana* cultivars: (a) metaphase I in 'Verbanica', 2n=95; (b) metaphase I in 'Lennei', 2n=133; (c) (d) metaphase II (juxtaposed) and metaphase I in 'Rustica', 2n=152. (530 X).

The relatively good fruit set to open- and self-pollination in 'Lennei' had led several investigators (McDaniel, 1967, among others) to assume that other fertile *soulangiana* cultivars, such as 'Rustica', 'Grace McDade', and 'Lombardy Rose' were also hexaploids. The formation of a cytologically stable, fertile hexaploid derivative from a pentaploid hybrid, with or without backcrossing, presents an intriguing situation.

The present investigation was undertaken to determine the chromosome numbers and chromosome pairing relationships in both fertile and sterile cultivars of *M.* x *soulangiana*, in the hope that some light might be shed on the origin of the fertile forms.

Flowers were fixed in 1:3 acetic acid-alcohol plus ferric chloride, and stored in this mixture at 2°C. Standard aceto-carmine squash techniques were used to study meiosis in the anthers. Pollen sterility was based on morphology and aceto-carmine staining of 200 pollen grains. Average diameters of sound, oval pollen grains were determined from measurements of the long and short diameters of 20 to 40 randomly-selected grains.

Results and Discussion

Data on pollen size, pollen abortion, and chromosome number are given in Table 1 for 8 *soulangiana* cultivars and representatives of the parent species.

Chromosome determinations in the parent species agreed with previous counts and no abnormalities of meiosis were noted. Pollen fertility was generally high, but pollen size could not be used to differentiate between the tetraploid and hexaploid species.

Four of the *soulangiana* cultivars, 'Alba', 'Alexandrina', 'Superba Rosea', and 'Verbanica', were pentaploids with 2n=95 chromosomes. Pairing configurations of 'Verbanica' (Fig. 1a) may be considered typical for this group and included 10 I (univalents), 35 II (bivalents), and 5 III (trivalents).

The number of chromosomes involved in univalent and trivalent associations indicates that at least one of the *M. denudata* genomes was quite distinct from either of those of *M. liliflora*. Actually, it is impossible to determine whether the majority of bivalents represent pairing between chromosomes from the same or different species.

All of the pentaploid cultivars produced a small percentage of extremely large pollen grains but only in 'Alexandrina' (which had about 10% large pollen) was the number of such grains sufficient to be reflected in the average pollen diameter. The large grains, up to 57 μ in diameter, appeared to result from a failure of the second meiotic division. Data on pollen abortion given in the table must be considered a minimum estimate, since there may have been many

Table 1. Chromosome and pollen data for eight *M.* x *soulangiana* cultivars and their parent species.

Species and Cultivar	Arboretum Number (NA-)	Pollen		Chromosomes	
		Size	Abortion	Ploidy	Diploid Number
Magnolia liliflora		Microns	Per cent		
'Darkest Purple'	3162	39.9	4	4x	2n=76
'Nigra'	2901	41.8	11	4x	2n=76
denudata	11149	42.8	2	6x	2n=114
x *soulangiana*					
'Alba'	2852	42.7	40	5x	2n=95
'Alexandrina'	11138	47.3	45	5x	2n=95
'Superba Rosea'	25363	43.5	14	5x	2n=95
'Verbanica'	10887	42.1	23	5x	2n=95
'Lombardy Rose'	9670	46.7	8	6.5x	2n=123
'Lennei'	1318	47.4	5	7x	2n=133
'Grace McDade'[a]	9671	47.6	4	7x	2n=133
'Rustica'	19773-4	51.6	4	8x	2n=152

[a]Our specimen of 'Grace McDade' does not agree with the description of that cultivar in Domoto (1962).

minor morphological abnormalities that were overlooked that might have been indicative of non-functional pollen.

Among the cultivars with high pollen fertility, 'Lennei' was found not to be a hexaploid as previously reported, but rather a septaploid (7x) with 2n=133 chromosomes (Fig. 1b). 'Grace McDade' was likewise a septaploid, while 'Lombardy Rose' was 6.5 ploid (2n=123). 'Rustica' was an octoploid (8x) with 2n=152 (Fig. 1c, d).

It should be mentioned that the chromosome counts on the hybrids are approximations based on careful drawings of at least five well-spread cells at metaphase of the first meiotic division. Because of the wide-spread occurrence of multivalent associations, it was virtually impossible to determine the precise number. When the average count fell within plus or minus two chromosomes of an exact multiple of 19, that level of ploidy was assigned to the cultivar in question. The count of 2n=123 for 'Lombardy Rose' is an average of seven determinations on that cultivar. Occasionally, in addition to counts at first metaphase, it was possible to obtain well-stained figures at second metaphase where the juxtaposition of nuclei allowed for the counting of all chromosomes in mostly bivalent associations (see Fig. 1c). Counts at this stage were in agreement with other determinations.

Since the parent species of the *soulangiana* pentaploids are tetraploid and hexaploid, it is likely that any gametes with fewer than 38 chromosomes (2x—as from tetraploid plants) would not be functional. Furthermore, because of random distribution of chromosomes, the number of chromosomes in viable pollen or egg cells would, of necessity, have to be greater than 38 for all essential genic material to be included.

Counts at metaphase II in the pentaploid hybrids showed a bimodal chromosome distribution pattern. An average of 42 and 53 chromosomes were found in the diad nuclei when the chromosomes were distributed unequally. This occurred in 62% of the cells. About 23% of the cells contained diad nuclei with 47 and 48 chromosomes, a nearly equal distribution. Chromosome loss at the first division could be detected in only 15% of the cells examined. Further chromosome loss and unequal distribution at the second division could result in microspores with fewer than 42 and more than 53 chromosomes. Cells with lower numbers would probably be inviable while those containing a genetically balanced complement would be functional. Failure of the second division, a common occurrence in these hybrids, could lead to the production of pollen grains with about 76 to 114 chromosomes; with modal numbers near 84, 95, and 106.

The high frequency of univalents and multivalent chromosome associations in those cultivars above the hexaploid level suggests that they were derived from the union of aneuploid gametes of pentaploid parents. If any of these cultivars had resulted from backcrossing to one of the parental species, chromo-

some pairing would be mostly bivalents. For instance, if the septaploid 'Lennei' were the product of a backcross to *M. liliflora*, this would require a 38-chromosome gamete from *liliflora* and a 95-chromosome gamete from a pentaploid *soulangiana*. The *soulangiana* gamete would most likely arise from a failure of the second meiotic division of a diad nucleus with ca. 47 chromosomes. Thus, since autosyndetic pairing of the *liliflora* chromosomes is possible, and practically all of the *soulangiana* chromosomes would have identical partners, there should be almost complete formation of bivalents. However, 'Lennei' (Fig. 1b) shows about 10 univalents and multivalent associations of up to 8 chromosomes.

It has long been believed that 'Rustica' arose as a seedling of 'Lennei'. Also, Domoto (1962) has stated that 'Lombardy Rose' was a 'Lennei' seedling. Based on present evidence, this is entirely possible. Since 'Lennei' is self-fertile, nearly octoploid or septaploid progeny could be produced by selfing or crossing with one of the pentaploid cultivars. However, it is also theoretically possible to obtain octoploids by selfing or crossing among pentaploids. If there were any advantage to be gained by the production of aneuploids, controlled crossing among *soulangiana* cultivars would produce a wide range of material.

As can be seen in the table, pollen fertility of the cultivars above the pentaploid level was quite high. In addition, the pollen grains were fairly uniform in size within the same cultivar. Pollen size was generally larger than the hexaploid parent (*M. denudata*) and the pentaploid hybrids. The pollen of 'Rustica' was even larger than that of septaploid cultivars. Pollen size in the hybrids appears to be fairly closely correlated with chromosome number, but with a greater number of cultivars this relationship might not hold true. The high percentage of good pollen is merely an indication that all genes and chromosome segments essential for gamete viability are present, and does not reflect any give chromosome number. Undoubtedly there are many viable aneuploid grains that contain duplicated chromosomes or chromosome segments.

Even though fertility in a hybrid may not be a valuable or necessary horticultural attribute, the high percentage of good pollen in those cultivars above the hexaploid level suggests that they might serve as genetic "bridges" to introduce desirable genes from either parent into other species with which its own parent species may not be compatible. The great variation of gene combinations in the pollen of fertile *soulangiana* types might well include some that would allow crosses even with some species of the other subgenus.

Literature Cited

Domoto, Toichi. 1962. *Magnolia* x *soulangeana* hybrids. Jour. Calif. Hort. Soc. 23:45-47.

Janaki Ammal, E. K. 1953. The race history of magnolias. Indian Jour. Genet. Pl. Breed 12:82-92.

McDaniel, Joseph C. 1967. Self-unfruitfulness of some magnolias. Morris Arb. Bull. 18:64-69.

Santamour, Frank S., Jr. 1969. Cytology of *Magnolia* hybrids. I. Morris Arb. Bull. 20:63-65.

Whitaker, Thomas W. 1933. Chromosome number and relationship in the Magnoliales. Jour. Arnold Arb. 14:376-385.

Book Announcement

"Selected Guide to the Literature of the Flowering Plants of Mexico"

This monumental book by Ida K. Langman is now available directly from the Morris Arboretum.

The Guide has received highly favorable reviews in the United States, Europe, and Latin America since its publication as a Morris Arboretum Monograph in 1964. The American Library Association honored the work with the Oberly Memorial Award Citation as "the best current bibliography submitted in the field of agriculture or related sciences."

The fact that most of the approximately 20,000 items are annotated adds enormously to the value of the book, so that it has become the basic reference source for those seeking material published on Mexican flowering plants, be it concerned with systematics, floristics, plant geography, ecology, economic botany, ethnobotany, or even vocabularies containing plant names in many languages.

The entries are listed alphabetically by authors. Under each author, they are arranged chronologically. A subject matter index, subdivided in great detail, adds considerably to the usefulness of the 1015 page work.

The Guide, no longer available from the publisher (The University of Pennsylvania Press), is priced at $22.50, including packing and postage. Orders, with remittance, should be sent to: The Morris Arboretum, 9414 Meadowbrook Avenue, Philadelphia, Pennsylvania 19118, U.S.A.

Conradina verticillata Jennison is a native American plant recently introduced to horticulture. (Photograph by the author.)

Plants Commemorating Persons. I. Conradina

J. Angus Paxton Heeps

The introduction of wild plants into cultivation has always been close to the hearts of gardeners the world over. During the past century thousands of species of distant origin have been collected by both professional plant hunters and enthusiastic, highly skilled amateurs. Many of these were missionaries, particularly in China whence come so many of our most handsome and popular garden plants. In this series, based on plants and the men whose names they honor, it seems fitting that the very first should be not only a new introduction to gardens, but a native American plant—and one whose name commemorates a Philadelphia botanist—as well.

It is the author's conviction that *Conradina verticillata* Jennison possesses many of the characters that are considered essential in a good garden plant. Its garden value has not yet been fully explored, and a number of evaluations of its responses to cultivation have yet to be made; nevertheless, its beauty is such that learning of its traits under cultivation should be pleasureful.

History

The Genus *Conradina* was first described by Asa Gray in 1870. It contains four species: *C. canescens* (T. & G.) A. Gray, *C. grandiflora* Small, *C. puberula* Small, and *C. verticillata* Jennison. While the first three species are found over a fairly wide area of the Gulf Coast regions of Florida and Alabama, the endemic area of *C. verticillata* appears to be restricted to the Cumberland plateau of Tennessee and Kentucky. In 1930, Professor H. M. Jennison found "relic colonies in sandy banks along Clear Fork River [in] Fentress and Morgan counties [Tennessee] about 1 mile North of Rugby." However, considerable exploring in the same area and in similar habitats "failed to turn up other stations where this endemic grows." Although known for many years to the local inhabitants of that area as "Ground Rosemary" (It bears a striking resemblance to *Rosmarinus* of Europe, though it is dwarfed by comparison.), the plant did not receive a scientific name in botanical literature until Professor Jennison published a formal description in a paper to the *Journal of the Elisha Mitchell Science Society* in 1933.

E. Lucy Braun mentions having found this plant a few years later (1935) on the Kentucky side of the Cumberland plateau and also notes the probability of its extinction in that area due to the construction of the Wolf Creek Dam. More recently, in a letter to the American Rock Garden Society, published April, 1969, Mr. Leonard J. Uttal of Roanoke, Virginia states that he hopes to find *C. verticillata* on the slope of the Cumberland plateau in the extreme Southwest corner of Virginia.

Although mentioned in the second edition of Rehder's *Manual of Cultivated Trees and Shrubs*, there is no record of its cultivation at the Arnold Arboretum. It is possible that Professor Rehder was aware of plants collected by Mrs. J. Norman Henry in the late 1930's and cultivated in her garden at Gladwyne, Pa. It is fortunate indeed that such a collection was made, for since that time the T. V. A. lakes have, in all probability, taken their toll of a number of the remaining colonies. From the stock at the Henry Foundation for Botanical Research, cuttings were obtained for the Morris Arboretum by Dr. E. T. Wherry and Mr. John Dourley in 1964. The survival of this species, in cultivation at least, is assured for the time being. Dr. Wherry brought attention to this plant in an article published by the American Rock Garden Society in their bulletin for January, 1969. It is hoped that this *Morris Arboretum Bulletin* presentation will stimulate more interest in this fine plant.

Description

The following is Professor Jennison's original description of *Conradina verticillata*: An undershrub with diffuse branches, the lowermost rooting freely; stems cylindrical with brown bark that shreds and sloughs off as the branches enlarge; twigs 4-sided, rufous, at first puberulent; leaves linear, opposite, appearing fascicled, average length 17.0 mm, average width 1.2 mm (*exsiccatae*), margin revolute; dorsal surface glabrate, green, glandular-pitted, ventral surface hoary, midrib prominent; petiole inconspicuous, 1 mm or less in length; flowers 2-6 on short pedicels in loose verticils, or terminal; calyx 6-7 mm long, hirsute, strongly 13-nerved, the upper lip three-lobed, the lower two-toothed and slightly longer than the upper; corolla lavender, lower lip three-lobed and strongly spotted within, upper lip arched, retuse; stamens in two pairs, opposite, included within the upper lip, filaments curved, anthers versatile, parallel; style forked, slightly exserted; nutlets 4, sphaeroidal, smooth, brown, about 1 mm in diameter. Blooms in May.

There is no mention in this technical description of the plant's aromatic fragrance of the leaves and stems, which appears to be highly distasteful to rabbits and has provided for another of its common names, "Upland Rabbit-Bane." This characteristic is also omitted in descriptions found in other publications.

In the Philadelphia area, the flowering period can last up to five weeks in cool seasons, commencing in late May or early June. During the winter, the leaves turn a discolored brown-grey but are persistent; it cannot therefore, be described as a truly deciduous species despite its somewhat bare appearance during the winter months.

Propagation

Propagation of *Conradina verticillata* is easily effected by softwood cuttings 2-3 inches in length taken during July. There appears to be small advantage in the use of either hormones or mist units since a cutting struck in sand will provide a vigorous plant ready for potting-up in three to four weeks. Plants from the cutting bench should be placed in 3-inch pots and immediately pinched to promote side shoots. Regular pinching back from subsequent side shoots not only produces a fine bushy plant but provides a fresh stock of cuttings for propagation; thus a large stock of plants may be quickly obtained. It is possible to continue propagation of this plant throughout the winter if so desired. This is achieved by bringing stock plants into the greenhouse in late

autumn, giving them a light feeding once every two weeks, and supplementary lighting (See under cultivation.). Cuttings have been rooted at the Morris Arboretum during every month of the year with a healthy rooting average 98-100 per cent.

If taken from the cutting bench and put into 3-inch peat pots, potting-on should not be necessary if plants are kept in a cool greenhouse until ready for planting out in May. Care should be taken to see that they are not allowed to dry out at any time, and regular feeding with an all-purpose fertilizer must be maintained.

As mentioned earlier, *Conradina verticillata* does tend to layer itself after two or three years; this provides yet another method of propagation. However, unless there are specific reasons for wishing to propagate it by this method, it should not be regarded as an efficient or economic proposition.

Cultivation

The most important requisite for this plant is good drainage. A deep, sandy, well drained soil, preferably acid, in a sunny open situation is ideal. If planted in full or even partial shade, one must expect some sacrifice of its full flowering potential. It is perhaps best suited to the rock garden, although its use in edging of borders close to the house might be considered. Its entirely prostrate habit has prompted us to consider this plant for use as a ground cover and trials for its use in this category will begin during the spring of 1971. Rooted cuttings have been sent to many other institutions in this country for this purpose as well as to discover its reaction to hot dry climates and severely cold ones. Plants were recently delivered to the Royal Botanic Gardens, Edinburgh, and the Royal Horticultural Society's Garden at Wisley; we trust they will respond favorably to the more erratic, though less severe climate of Britain.

Conradina verticillata has survived quite happily in the Philadelphia area proving itself adaptable to our temperature extremes. For the present time we must remain optimistic about its survival in other locations.

Since this plant flowers on its new growth, pinching shoots to promote a more bushy plant should be delayed until after flowering in June. Fertilizer may be applied during the spring but is not recommended for the fall.

Tests with three batches of plants have shown that this species is quite suitable for forcing. Cuttings taken September 26, 1969, and potted October 20, 1969 were placed under fluorescent lighting November 20, of that year. Fifteen hours of supplementary lighting were given in addition to nine hours normal daylight. First flowers were observed January 20, 1970, after which many more were produced in profusion, lasting three weeks. Had the plants been removed to a cooler greenhouse without supplementary lighting after the first flowers had appeared, we would undoubtedly have enjoyed a far longer period of flowering. All plants tested were given a weekly feeding with a liquid fertilizer (20:20:20) and kept at a minimum night temperature of 70°F (21.1°C). Control plants were given precisely the same conditions except for fluorescent lighting. Further tests showed that as fluorescent lighting hours were decreased so also did the number of flowers. Control plants showed little growth of side shoots when compared with forced specimens. Fluorescent lighting might therefore be considered as a useful tool in the production of side shoots for propagation purposes.

It is our hope to interest the nursery trade in this plant by distributing rooted cuttings to those nurserymen who feel it to be worthy of introduction. Potted plants were distributed to Associates of the Morris Arboretum on the Annual Plant Distribution Days in May, 1970.

Solomon White Conrad

Solomon White Conrad in whose honor this plant was named, was a descendant of Thones Kunders (later anglicized to Dennis Conrad) who emigrated from Crefeld, Germany in 1683, settling in Germantown. Solomon Conrad was born July 31st, 1779, the son of John Conrad, a blacksmith. Though little is known of his early life, we do know that his business career came to an abrupt close when his partner ruined him financially.

He had early in life acquired a love for the outdoors, to which he now turned in earnest, soon to gain considerable respect for his knowledge both as a botanist and mineralogist. Described by a contemporary as an "amiable man" and an "excellent botanist," Conrad was among the first American botanists to "attempt to group our plants by the natural method." His collection of herbarium specimens is now in the possession of the Philadelphia Academy of Natural Sciences.

At the age of 24 years his first son was born and christened Timothy Abbot Conrad. He too, grew to be a prominent naturalist of his day, not in the field of botany, but in conchology and paleontology, publishing many papers on tertiary and cretaceous geology and paleontology.

Solomon White Conrad was elected as Professor to the Chair of Botany in the University of Pennsylvania March 21st, 1829. An account of his introductory address published in *The Friend*, written by Mr.

Robert Vaux, gives us some insight into the character and ability of Conrad. "With a succinct review of the history of botany, he very happily blended some biographical notices of the distinguished men to whom science owed its origin and illustration. He traced with great acuteness and perspicuity, the analogy of vegetable and animal life, admitting the limit of human knowledge. Every view that he furnished of the subject, upon which he is so well qualified to impart instruction, was just and forcible, while the simplicity of his manner and chasteness of his style were, by no means, the least interesting traits of the lecturer."

Absence of biographical data prevents a more detailed description of Conrad as a man and of his contributions to the science of botany. He died October 2nd, 1831 at the age of 52 after occupying the Chair of Botany for only two years.

Literature

Abbott, Charles C., 1895. Timothy Abbot Conrad. Popular Science Monthly. XLVII: 257-263.

American Rock Garden Society Bulletin, 1969. Conradina Again. 27: 64.

Braun, E. Lucy. 1937. Some Relationships of the Flora of the Cumberland Plateau and Cumberland Mountains in Kentucky. Rhodora 39: 196-7.

____. 1943. Annotated Catalogue of Spermatophytes of Kentucky. University of Cincinnati. 161 pp.

Harshberger, J. W. 1899. Botanists of Philadelphia. (Press of T. C. Davis & Sons.) Philadelphia. 457 pp.

Jennison, H. M. 1933. A New Species of *Conradina* from Tennessee. Journal of the Elisha Mitchell Science Society 48: 268-9.

____. 1935. Notes on Some Plants of Tennessee. Rhodora 37: 309-310; 321.

Rehder, A. 1958. Manual of Cultivated Trees and Shrubs. Macmillan. New York. 2nd Edition. 996 pp.

Small, J. K. 1933. Manual of the Southeastern Flora. Published by the author. New York. 1554 pp.

Wherry, E. T. 1969. Plants to Know and Grow. *Conradina verticillata*—Upland Rabbit Bane. American Rock Garden Society Bulletin. 27: 29-30.

Two Hybrid Hollies

Included in our collection of plants distributed to local Associates of the Morris Arboretum on Plant Distribution Days, May 22, 23, 1970 were the two choice cultivars of holly named 'John T. Morris' and 'Lydia T. Morris'. According to Dr. Henry T. Skinner, Director of the National Arboretum in Washington, these cultivars are sister seedlings from a cross between *Ilex cornuta* Lindl. *burfordii* (S. R. Howell) De France and *I. pernyi* Franch. made at the Morris Arboretum in 1948 and later distributed from the National Arboretum. Both of the parental species, of considerable ornamental value individually, are native to China. The hybrids exhibit the pleasing pyramidal habit of *I. pernyi*, the dense branching of *I. cornuta*, and the elegantly lustrous leaves characteristic of both species.

A. Orville Dahl

About Our Authors

(Continued from page 50)

J. Angus Paxton Heeps, a graduate of Wisley, now Superintendent of the Morris Arboretum, joins *Dr. Edgar T. Wherry*, Professor Emeritus, Pennsylvania, and *John Dourley*, former Superintendent of the Morris Arboretum, in recognizing the outstanding ornamental potential of *Conradina verticillata*. This native American plant is fast becoming decimated in its own habitats. It is thus doubly fitting that the Morris Arboretum should introduce it to horticulture both here and abroad. Among the first persons to claim it for their gardens were those Associates of the Arboretum who selected it on a Plant Distribution Day this spring.

Lester P. Nichols is Professor, Plant Pathology Extension, The Pennsylvania State University, specializing in diseases of ornamental plants. For the past several years he has made annual visits to the Morris Arboretum to observe our crab apple trees.

Disease Resistant Flowering Crab Apples

LESTER P. NICHOLS

The flowering crab apples are among the best of the ornamental trees and are valued for flowers, foliage, fruit and variations in size and habit of growth. They are well adapted for use in park and parkway plantings, private grounds, and any place where community beautification is desired. Unfortunately, many of the flowering crab apples which have

Fig. 1. Apple Scab of crab apple leaves.

the prettiest flowers or the most ornamental fruit are very susceptible to and may be severely injured or rendered unsightly by one or more of four common diseases. These diseases are Scab, Cedar-Apple Rust, Fire Blight, and Powdery Mildew.

The leaf symptoms of Scab, caused by the fungus *Venturia inaequalis*, are dull, smoky areas which change to olive green moldy spots, usually without definite margins (Fig. 1). The leaves may turn yellow and fall prematurely. On fruit, the spots are small, round, dark-olive areas which, as they increase in size, become corky in the center.

The fungus overwinters in fallen leaves. During spring rains, spores are ejected from fruiting bodies in old leaves and are carried by air currents to newly opened leaves. Because another type of spore develops by the thousands in each leaf spot, the disease can increase in intensity during the growing season.

The Scab disease is found and may be serious wherever crab apples are grown. However, since the causal fungus overwinters only in fallen leaves, newly planted trees received from the nursery in the dormant stage may remain free of the disease for several years, especially if there are no diseased crab or regular apples growing nearby. Certain of the crab apples, such as *Malus* 'Almey', *M. purpurea eleyi, M.* 'Hopa', *M.* 'Jay Darling', and *M.* 'Strathmore' are extremely susceptible to Scab.

Cedar-Apple Rust, incited by the fungus *Gymnosporangium juniperi-virginiana*, causes orange areas one-eighth to three-fourths of an inch in diameter on leaves (Fig. 2) and fruit. The upper surface of these areas on leaves is covered with minute black dots within a reddish circle. On the under surface of the leaf, and also on the fruit, the orange spots may have many small, cup shaped structures with fringed edges (Fig. 3). In late summer, spores from the cups are blown to and initiate disease of Red Cedar and other juniper trees where, after 18 to 20 months, a different type of spore is produced on galls. These are disseminated to crab and apple trees once more.

Severe disease of leaves and twigs may cause early leaf fall and dwarfing of the trees. On Bechtel's Crab, which is very susceptible to the disease, Apple Rust is usually a problem only in areas where there are large numbers of native cedars or plantings of ornamental junipers growing within a mile of the crab apples.

Fire Blight, caused by the bacterium *Erwinia amylovora*, results in sudden wilting, dying, and browning or blackening of new shoots. The leaves on these shoots die, hang downward, and cling to the blighted twigs (Fig. 4). The disease usually becomes more serious when the crab apple trees are planted near pears, which may harbor the disease-causing bacteria. Among the crab apples which are very susceptible to Fire Blight are *Malus hupehensis, M.* 'Van Eseltine', and *M. zumi calocarpa.*

Fig. 2. Cedar-Apple Rust of crab apple. Note the tiny dark dots in the lesions. These form on the upper surface of the leaf.

Fig. 4. Fire Blight of twigs of crab apple.

Fig. 3. Cedar-Apple Rust of crab apple. The under surface of this leaf is shown where the rough appearance of the lesions is due to clusters of cuplike spore-forming sites.

Fig. 5. Powdery Mildew of a crab apple shoot. The fungus distorted the terminal leaves and caused localized bulges in others.

The Powdery Mildew fungus, *Podosphaera leucotricha*, appears on the terminals of the branches and on the leaves as a white powdery coating. Severely affected leaves may be badly distorted (Fig. 5). On susceptible cultivars such as *Malus* 'Almey', white powdery patches of the causal fungus may be found on the fruit.

Powdery Mildew is usually a problem on crab apples only in locations where the air movement around the trees is poor or where they are growing near orchards of susceptible apples such as 'Cortland' or 'Rome'.

There are effective spray materials available for the control of each of these diseases; however, the sprays must be applied several times, and often the critical, correct time of application interferes with the busy spring season of the nurseryman so that the sprays are delayed or not put on at all. Also, since most home owners are not equipped to spray trees or do not have access to the spray materials, they must depend on the services of custom spray operators who may have difficulty in maintaining a spray schedule which permits them to treat the trees of all customers at the correct time.

Many of the species and cultivars of crab apple show a marked degree of resistance to the four common diseases while others show a decided susceptibility. In an effort to find crab apples which show resistance and would not have to be sprayed for disease control, I am making a continuing survey each year of crab apple plantings in a seven-state area of the Northeast. In the list below are crab apples which were found to be free of Scab, Cedar-Apple Rust, Fire Blight, and Powdery Mildew during the eight years of the survey.

Only those crab apples which, *in addition to being resistant* to four diseases, also *are available* at one or more commercial nurseries are listed first. Then comes a list of six that warrant planting in spite of being susceptible to certain diseases.

Crab Apples Found To Be Free of Diseases During an Eight-Year Period

Malus 'Adams'

M. baccata 'Jackii'—Excellent white flowered; glossy, red-fruited; upright, Siberian type.

M. 'Beauty'—Single white flowers, bright red fruit; may be an alternate-year bloomer.

M. 'Beverly'

M. 'Centennial'

M. 'David'

M. 'Ferrill's Crimson'—Single, purplish-red flowers; fruit red; leaves bright red. Not an outstanding ornamental.

M. 'Golden Hornet'—Single white flowers; yellow, persistent fruit which may become russetted in the autumn.

M. 'Ormiston Roy'—Single, pink flowers; yellow, persistent fruit; an annual bearer.

M. 'Pink Spires'

M. 'Red Splendor'—Carmine buds and flowers, fading to dull pink; red fruit.

M. 'Royalty'—One of the best purple-leafed crabs.

M. 'Spring Snow'

Crab Apples That Warrant Planting in Spite of Being Susceptible to Certain Diseases

Malus floribunda—slightly susceptible to Scab and Powdery Mildew and moderately susceptible to Fire Blight; an annual bearer with deep pink to red buds opening to single white flowers; blooms while comparatively young; fruit is yellow and red, 3/8" in diameter.

M. sargentii—slightly susceptible to Scab and Fire Blight; pure white, fragrant flowers; dark red fruit; a densely branching crab that may grow twice as broad as it is high.

M. 'Selkirk'—slightly susceptible to Scab, moderately susceptible to Powdery Mildew; purplish-pink flowers; has one of the glossiest bright red fruit of any of the crabs; may not be an annual bearer.

M. sieboldi 'Fuji'—moderately susceptible to Scab and Powdery Mildew; abundant double, white flowers; colorful medium-sized fruit which may remain on the tree all winter.

M. 'Snowdrift'—moderately susceptible to Fire Blight; pink buds, then pure white flowers; orange-red fruit 3/8" in diameter; lustrous green foliage; one of the best white crab apples.

M. 'White Angel'—slightly susceptible to Fire Blight; pure white flowers; glossy red fruit; lustrous green foliage; one of the best white crab apples.

Erratum

In Volume 21, No. 2, page 24, Fig. 1 is a photograph of *Acer buergerianum*, the Trident Maple at the Morris Arboretum, *not A. truncatum*.

Morris Arboretum Bulletin

LEGES SINE MORIBUS VANAE

Vol. 21 DECEMBER, 1970 Number 4

Dionysus, son of Zeus, still rides his grape-adorned panther in this ancient floor mosaic on Delos Island. According to legend, it was Dionysus who discovered The Vine and introduced viticulture not only in Greece but as far east as India.

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About Our Authors

Carl W. Haeseler, Ph. D. The Pennsylvania State University, studied also at the University of Massachusetts and Cornell University. He has worked for 10 years with The Vine and enjoys studying its unique responsiveness to various horticultural practices. The future for research in viticulture in Pennsylvania appears especially promising because of recent legislation that is encouraging the growth of the wine industry. The home garden cannot fail to benefit from such research.

Frank S. Santamour, Jr., Ph. D. Minnesota, published the first two parts of the series on Magnolia in earlier issues of the *Bulletin* (December, 1969; September, 1970). They dealt with interspecific crosses of members of different sections of the genus. The investigations were made at the National Arboretum, Washington, D. C., where Dr. Santamour is Research Geneticist.

VITICULTURE FOR THE AMATEUR IN PENNSYLVANIA

Carl W. Haeseler

Commercially, production of grapes in the State of Pennsylvania is principally for juice purposes. Therefore, 95 to 98 per cent of the grapes produced are the cultivar 'Concord' (*Vitis labrusca* L.). Consequently, the commercial area of grape production in Pennsylvania is centered in Erie County. This area has distinct definition in that it is located within a strip of land 40 miles in length and three to five miles wide, bordering the southeastern shore of Lake Erie. The primary reasons for such specificity are the cold lake waters that maintain low air temperatures in the spring and effectively retard bud burst and blossoming, thus lessening the danger of crop loss due to spring frost. Yet, in the autumn, the opposite is true, in that the warm lake waters modify the air temperatures enough to delay the occurrence of early frosts. In addition, nearly continuous air movement keeps vine foliage and fruit dry which aids in deterring fungous diseases. Also, temperature extremes during the winter and spring usually are minimal.

Yet grapes are grown commercially outside the "Grape Belt." There are a number of growers in south-central and southeastern Pennsylvania who supply limited quantities of grapes for fresh consumption. These people, in most instances, produce grapes for roadside stand sales.

Still another interest which recently has come to the fore again is that of producing wine grapes. Interest in this particular phase of viticulture is keen, not only in Pennsylvania everywhere that the grape is currently in production, but also in those areas where the grape had once been grown successfully, but succumbed either to winter injury, insects and disease, or to various combinations of these factors. At present, there are three wineries in Pennsylvania, but others are in the planning stage. Two of these wineries, Penn Shore Vineyards and Presque Isle Wine Cellars, are located in Erie County. The other, Conestoga Winery, is located in Birchrunville, Chester County.

A final, but extremely important and enthusiastic group is made up of amateurs. These grape growers are located in all areas of the State.

Prior to discussing the culture of the grape, it would seem appropriate to present a brief account of the history of the grape in Pennsylvania, as it is quite colorful.

Pennsylvania Grape History

Several authors have written about the journey of the grape in the eastern United States. According to these accounts, in the mid-1600's, Queen Christina of Sweden instructed John Printz, Governor of New Sweden, "to encourage the culture of the vine and give it his personal attention." The area of New Sweden currently would include Delaware County, Pennsylvania, and the Wilmington region of Delaware. Shortly after acquiring his colony in the area of Philadelphia, William Penn imported grape cuttings from France and Spain and established several experimental vineyards. None of these experiments was successful. In fact, it was not until the 1790's that any success was achieved with the European grape in Pennsylvania. This was accomplished by Peter Legaux, a Frenchman, who founded a company for the cultivation of the grape in 1793. His four-acre vineyard was located in Spring Mill, thirteen miles northwest of Philadelphia, on the Schuylkill River. In spite of his ability as a vineyardist, he was successful with only one variety which he called the "Cape Grape" or "Cape Madeira." Actually, this variety was determined to be a cross between a European and an American grape named 'Alexander'. Nevertheless, Legaux was the chief disseminator of the first distinctive commercial American grape variety and was responsible for the early success of the wine grape in Pennsylvania. About that time, other vineyards were planted around Middletown, and in the early 1800's, the Harmonists, immigrants from Germany, attempted to grow wine grapes around Pittsburgh, but failed.

York has been credited with being one of the first, if not the first, extensive center of native grape production in America. In 1818, Thomas Eichelberger set out four acres of grapes, primarily the 'Alexander', and by 1826 there were about 150 acres of grapes in and around York. Adams, Chester, Lancaster, and Westmoreland counties also had acreage planted to grapes. The 'Alexander' grape eventually was replaced by the 'Catawba' and 'Isabella' varieties. It is reported that the grape industry in this area finally succumbed to losses caused by disease. Nevertheless, York and Lancaster counties are considered among the starting places of American viticulture.

Failure of the Old World grape was attributed primarily to *Phylloxera vastatrix*, a root louse, to mildews, Black Rot, and, quite likely, to winter temperatures. Hedrick stated, "It is probable, too, that our climate, at the North at least, is not well suited to the production of the Old World grape. As a species, Vinifera grapes thrive best in climates equable in both temperature and humidity. The climate of eastern America is not equable; it alternates between hot and cold, wet and dry."

Grape growing ventured from the York area into the Finger Lakes section of New York in 1830 when the Reverend William Bostwick planted the first vines at Hammondsport. Commercial grape production actually started around 1853 in that area when Andrew Reisinger, a German grower, set out 'Catawba' and 'Isabella' vines in Harmonyville, a few miles north of Hammondsport.

Prior to this time, in 1818, the Reverend Elijah Fay from Southborough, Massachusetts set out his 'Fox' grape in Brocton, New York, along the southern shore of Lake Erie. This variety was unproductive and commercial grape growing really did not start in the Lake Erie area until around 1824.

The first grapevines in North East, Pennsylvania were set out by Messrs. Hammond and Griffith in 1850, which was also about the time the 'Concord' grape was introduced for commercial trial. In 1869, the South Shore Winery was established, lasting until 1914 or 1915, at which time its stock was sold to Grimshaw's Winery. The latter was forced to close as a result of the 1917 prohibition legislation. Since prohibition, the primary emphasis has been on the production of grapes for fresh consumption and juice. From that time to the present, the 'Concord' has been king of the eastern grape industry.

Climate and the Amateur

Although less important from the viewpoint of the amateur, climatic factors nonetheless should be given some consideration. Commercially, of course, local climatic conditions are of paramount importance. What climatic factors should be considered? Perhaps the most important single factor is that of temperature. As far as winter is concerned, frequency of site exposure to −5° F or lower will determine to a large degree whether or not certain species or cultivars will thrive in any given area. *Vitis vinifera* L. cultivars are quite sensitive to temperatures of −5° F or lower. Although the majority of French-American hybrids presently being grown at The Pennsylvania State University Agricultural Experiment Station at North East, Pennsylvania appear to have survived one of the coldest winters on record for that area, some of the hybrids will not survive well in areas that are *frequently* exposed to −5° F or lower.

The amateur is able to select small sites in his garden that differ widely from one another in temperature, soil, and light conditions—"microclimates"—so to speak. Careful selection of a site can aid in reducing the amount of winter damage. Choosing one that is protected from the prevailing cold winter winds and that has good air and soil water drainage will certainly increase the degree of success in growing grape cultivars that are known to be sensitive to low winter temperatures.

Fig. 1. Fruiting habit of a 'Concord' grapevine.

Spring temperatures may affect vine performance in several ways. Warm temperatures in early spring can start activity and result in bud swell and even some shoot growth. If bud swell and shoot growth should take place too early, there is a real chance that these tender buds or succulent shoots could be lost due to a late spring frost or freeze. Therefore, the relationship that exists between the occurrence of early shoot growth, time of bloom, and the average date of the last spring frost is important.

Occurrence of the first autumn frost, of course, determines the length of the growing season, and, consequently, may also limit the selection of varieties to be grown in a given area.

Variety Selection

Variety selection for the non-commercial viticulturist ultimately will be based on his personal preference and what use is to be made of the grapes—juice, table, or wine. Except for juice purposes, there are several suitable varieties available. For juice, jellies, and preserves, the 'Concord' remains supreme (Fig. 1).

Wine grape cultivars are numerous. However, the availability of these plants is limited. For ease of growing, especially with respect to winter injury and *Phylloxera* (root louse) problems, the American types and the French-American hybrids are preferred. From a strict quality viewpoint, several *Vitis vinifera* cultivars are worthy of trial.

American varieties: *'Delaware'* is a red-fruited variety with small clusters and small berries. It is one of the better white wine varieties if fermented and fined (clarified) properly, as well as being a high-quality dessert grape. It is an early-season variety. A substitute for 'Delaware' might be *'Moored'*. *'Dutchess'* is a white-fruited variety having fairly compact, medium-sized clusters. Berry size is small to medium. It is one of the best American white wine varieties, although it is sensitive to low winter temperatures, especially when grown in poorly drained soils. *'Kendaia'* is an early-season, high-yielding 'Concord' type blue grape. Berries have a slight tendency to crack. It is one of the hardiest varieties available. *'Buffalo'* is an early-season variety of high dessert quality. Clusters usually are loose, but vines are productive and have a tendency to overbear. There is some indication that it exhibits resistance to Black Rot. It is not an especially hardy variety. *'Van Buren'* is a blue-black 'Concord' type grape which ripens two weeks or so before 'Concord'. Vines are as vigorous as 'Concord' and it is one of hardiest. It is also attractive to birds and susceptible to Downy Mildew (Fig. 2). A possible substitute for 'Van Buren' is *Virginia Polytechnic Institute (VPI) No. 30*. *'Himrod'* is an early, seedless, white grape of excellent quality. It tends to develop straggly clusters unless cluster- and berry-thinned. Fruits are medium in size. The moderately hardy, vigorous vine requires good protection from insects and disease. *'Niagara'* is a white-fruited variety usually displaying handsome, compact clusters. It has excellent vine vigor. Fruit is of high table quality if allowed to ripen fully on the vine. It ripens just before 'Concord', but is not as hardy as 'Concord' and also is susceptible to Black Rot. *'Concord'* is a mid-season blue-black grape that bears medium-sized clusters of medium-sized berries. *'Steuben'* is an

excellent quality grape for both dessert and wine. It is outstandingly vigorous and productive. Clusters are slightly larger than 'Concord' and the fruit resists cracking. It does have a tendency to overbear and is susceptible to Black Rot. It is a mid-season variety. A possible substitute for 'Steuben' is *VPI No. 31*. '*Naples*' is a late-ripening red grape that closely resembles 'Delaware', which is one of its parents. Usually, clusters and berries are larger than those of 'Delaware' and it ripens about two weeks later than 'Delaware'. It has a strong tendency to overproduce. '*Yates*' is a fairly hardy, red variety which is quite vigorous and productive. Berries are large, and when well-ripened, the quality is good. This variety will maintain its quality in storage longer than any other American grape. It ripens along with '*Catawba*', a late variety of light red grape. Legend has it that the Lost Roanoke Colony cultivated 'Catawba' along the banks of the Catawba River in North Carolina where it was rediscovered in the early 1800's. When the juice is properly ameliorated (diluted with sugar-water), a distinctive, fragrant, sweet white wine can be obtained.

French-American Hybrids: *Seibel 5279* ('Aurore') is a small-berried white grape with long and cylindrical clusters that vary from loose to compact. It is quite productive and vigorous on well-drained soils. It is an early variety, ripening before 'Delaware'. It grows upright and suckers freely, especially when pruned heavily. It is quite hardy. *Seibel 9110* is an early mid-season, white grape with fairly large clusters that have a tendency to be loose. Berries are ovate and crisp. On well-drained, deep soils, the vines are quite vigorous and fairly productive, but not especially hardy. *Seibel 10878* ('Chelois'), a mid-season grape, is vigorous, productive, and fairly hardy. It is a blue-black grape with medium-sized bunches which are fairly compact. At present, it is one of the more popular red wine varieties. *Kuhlmann 188-2* ('Marechal Foch') is a small, black-fruited, early wine variety that develops very compact clusters. Vines are vigorous and hardy. It is susceptible to bird damage; therefore, it may have to be harvested before attaining optimum maturity. *Seyve-Villard 5276* ('SV-Seyval Blanc'), pictured on the title page, is a mid-season, white, fairly large-fruited variety. Clusters vary in compactness, but, when grown well, are fairly compact. Vines are vigorous in well-drained, deep soils, but not in shallow soils that are poorly drained. It is a fairly hardy wine variety. *Seyve-Villard 12375* ('Villard Blanc B') is a very large-clustered, white-fruited variety which ripens very late. Juice quality for wine purposes is acceptable. The vine is quite vigorous but not especially hardy. *Ravat 51* is another white variety which is quite productive, and although the juice is quite high in acidity, it produces a fine white wine. The grapes ripen in mid-season along with 'Concord'. Berries are small and are borne on medium-sized, compact clusters. It appears to be hardier than SV 12375, but not as hardy as SV 5276. *Vidal 256* is a late-ripening, white, small-fruited grape that has long, conical clusters which frequently are accompanied by a long, slender shoulder cluster. The juice is quite acid but usually develops into a good white table wine. The vine is vigorous, and may produce heavy wood whose buds may be somewhat tender, although it is considered to be fairly hardy.

Vitis vinifera: All varieties are very tender and should be grafted to phylloxera-resistant rootstocks. The '*Johannisberger Riesling*' or '*White Riesling*' is a white, mid-season to late-ripening grape that is considered one of the best white wine varieties available. It produces rather small, compact bunches. Buds and wood are considered very tender. It must be cluster-thinned to survive winters in the East. '*Pinot-Charddonnay*' produces an excellent white wine, and is a vigorous grower, but it appears to be variable in yield. Clusters are small and conical, with small, round berries. It is not cold-hardy and must be cluster-thinned. '*Pinot Noir*' is a moderately productive, early, black grape which is considered medium in vigor. The clusters are small and cylindrical, bearing medium-sized berries. This variety must be cluster-thinned to survive winters. Like other "viniferas," it is very tender to sub-zero temperatures. '*Cabernet-Sauvignon*' is a mid-season variety that usually bears small to medium-long conical, black-fruited clusters that vary in compactness. The vines are usually vigorous and productive. It is very tender and must be cluster-thinned.

Propagation

Propagation of the grape in general is limited to asexual reproduction by hardwood cuttings. Well-matured, dormant canes should be selected from normally productive, vigorous vines. Canes of American types should be approximately pencil-size in diameter between the fifth and sixth nodes and have an internode length ranging from four to six inches. Some of the French-American hybrids have shorter internodes than those of American vines. Cuttings should have a minimum of three buds and range from nine to twelve inches in length.

Cuttings of cold-sensitive varieties are usually taken in late autumn or early winter in order to avoid bud injury by low winter temperatures. Hardy vari-

eties, on the other hand, may be left until late winter or until just prior to setting the cuttings in the nursery row. Actually, one of the best ways to store cutting wood is to leave it on the vine until it is ready to be used. When making cuttings, make approximately twice as many as the number of plants desired.

In preparing cuttings for storage, cut at a 45° angle one to two inches above the top bud and straight across slightly below the bottom bud. After removing cuttings from storage, recut below the bottom bud when preparing the cuttings for setting in the nursery row. For storage purposes, cuttings should be

Fig. 2. Downy Mildew (pathogen, *Plasmopara viticola*) of a fruit cluster of a 'Fredonia' grapevine.

grouped 50 to 100 per bundle. The bundles should be buried in moist sawdust in a cold room maintained at a temperature of 32° to 35° F. If a cold room is not available, then cuttings may be stored in a moist, well-drained soil. After burying, butts up, cover the area with a straw mulch of eight to twelve inches. This will help to protect them from low winter temperatures.

The next spring select a site with a well-drained soil to place cuttings in a nursery row for rooting. Remove cuttings from storage and set them four to six inches apart in rows five feet apart. To set cuttings, make a furrow deep enough to insure that all buds except the top bud will be below the surface after setting in the nursery row. Be certain to firm the soil well around the cuttings as the furrow is back-filled. Maintain these plants in a good state of vigor by keeping them weed-free and free from insects and diseases. These cuttings should be developed well enough for planting in a permanent location the following spring.

Planting

Select plants with vigorous root systems so that they will become established quickly. Be certain to prepare the soil well and have it in a good state of tilth. Grapevines usually are planted in early spring and spaced six to eight feet apart in rows nine feet apart, if more than one row is to be used. When planting, make the hole large enough to accommodate the root system without cramping it. Remove broken or dead roots at this time, spread the roots in the hole, and cover them with top soil. Take care to firm the soil well about the roots. At planting, remove all canes but the most vigorous one and cut this cane back to eight or ten buds. Remove all but the two uppermost shoots when they are about one inch in length. If there is no strong cane or the one-inch shoots cannot be removed, prune to a single cane and cut this back to two buds at planting. It is mandatory to keep the soil in the immediate vicinity of the plants weed-free until a cover crop is sown in mid-July or early August.

The important thing to remember is to cultivate frequently enough to eliminate competition for water and mineral nutrients.

Training and Pruning

Trellises or arbors usually are constructed during the first growing season. Posts for trellises should be eight feet in length with a top diameter of two and one-half to three inches. Treated posts are preferred. End posts should be a little larger in diameter than line posts. Space posts up to 24 feet apart in rows nine feet apart. Set end posts two to two and one-half feet into the ground and anchor them well. Line posts may be set slightly less deep than end posts. After the posts are in place, No. 9 galvanized wire is fastened onto the windward side of the posts at the proper heights. The top wire should be five and one-half to six feet above the soil surface and the bottom wire two and one-half to three feet above the ground. If a third wire is to be used, place it midway between the top and bottom wires. With varieties that tend to send upright shoots, a wire is placed slightly below the top wire on the opposite side of the post to aid in containing shoot growth. Upright shoots are placed in between these two wires during the growing season.

There are many designs of arbors available. A very suitable one may be constructed of one and one-half inch galvanized iron pipe, No. 9 wire, and heavy galvanized fencing. The corner posts should be about 12 feet long, embedded two feet in the ground in concrete. The hole should be about 8 inches across. An arbor 11 or 12 feet wide, 12 to 16 feet long will accommodate four vines, two to a long side. Pipes

Fig. 3. Grapevine trained and pruned to the Umbrella Kniffin System.

connecting the tops of the uprights to one another are secured with standard fittings. Two strands of wire are strung on each of the long sides of the arbor. The roof is a length of galvanized fencing firmly fastened to the ends. Such an arbor permits efficient care of the vines, and displays the beauty of the foliage and fruit well.

Training and pruning of vines are usually carried out any time after leaf fall until shoots emerge in the spring. With cold-tender varieties, it is better to delay pruning until the danger of freeze is past, which would be late winter or early spring. *Training* is the systematic arrangement of strong, supporting vine parts on trellis wires so that vines can be conveniently managed and result in good production of high quality fruit. *Pruning* is the annual removal of wood to regulate and encourage good annual yield. The grapes develop on new shoots each year; these arise from buds on older canes.

Grapevines may be trained in various ways. Which system is the most desirable will depend on the growth habit of a given variety under a given set of growing conditions. Four popular systems of training are: *Umbrella Kniffin*, *Keuka High Renewal*, *Six-Arm Kniffin*, and the *Single Curtain Cordon*.

The Umbrella Kniffin System is established by bringing the trunk up to the top wire and leaving four canes near the top of the trunk (head) bearing a total of 50 to 60 buds. Remove all other wood except two renewal spurs (short canes, usually with one to three buds) near the head. Then cut the one-year wood that was removed (the prunings) into lengths of two to three feet and tie into a bundle. This bundle is to be weighed so that the number of buds to be left on the four canes of the vine can be determined. The standard method for doing this is as follows: For the first pound of one-year wood removed, leave 30 buds. For each additional pound of one-year wood removed, leave ten more buds. For example, a vine that had three pounds of one-year wood removed would be further trimmed until a total of 50 buds remained—30 for the initial pound, and ten for each additional pound, resulting in a total of 50 buds. Therefore, in this example, four canes, each with 12 buds, plus two renewal spurs should be left. After adjusting the number of buds, bend the canes rather sharply over the top wire and tie the tips to the bottom wire. Then tie the trunk to the bottom wire for support (Fig. 3). What will happen is this: The renewal buds will develop into shoots. These will be allowed to grow. They probably will not be fruitful, but that is not their purpose. They are there to be used, if necessary, when retraining. The 48 buds on the four arms (canes) will form fruiting shoots that do not need to be tied because the vine has already been trained. Some of these 48 shoots probably will be well located, and can replace the four original arms the following season, in which case the renewal shoots would not be needed.

The Six-Arm Kniffin System: When training a grapevine to this system, bring the trunk up to the top wire. Leave two canes—one in each direction for each wire—that arise at a point just below each wire. Leave 12 buds on each of the six canes. Then weigh the wood removed in pruning and adjust the number of buds accordingly. Tie the tips of the canes onto the wires. Occasionally more than one tie will be needed per cane to insure that the cane is well supported by that wire. Trunks should be tied to the bottom wire. Renewal spurs are seldom needed with this system.

The Modified Keuka High Renewal System is used with vines that are not particularly vigorous. In this system, a trunk is brought up to the bottom wire and two canes are positioned bilaterally along the bottom wire and are tied to it. When there is enough vigor, a single cane is brought up to the top wire and tied. New shoots must be tied during the growing season as they develop. Renewal spurs should be left after pruning.

The Single Curtain Cordon (No-Tie) System: Trellises for vines trained to this sytem will differ from those of the other three systems. A special wire should be used as the top wire. Preferably, this wire should be galvanized, crinkle wire or Basic Bright No. 8 wire that has the property of low stretchability. The reason for this is that once the Single Curtain Cordon System is established, the wire cannot be tightened from one year to the next. In training a vine to this system, select two strong canes or arms and place them bilaterally along the top wire. Arms from one vine should not overlap with arms from adjacent vines. If possible, during the first year, leave *five-bud spurs* and one *renewal bud* on the arm for each five-bud spur. These should be well-spaced along each horizontal arm. In selecting arms, be careful to avoid scored wood where canes crossed over the top wire. Use the regular pruning scale described under the Umbrella System. The fruiting shoots will hang like a curtain in groups of five from the spurs attached to the arms along the top wire. The arms should be wrapped loosely around the wire and tied at each end. One and one-half turns should be sufficient for each arm. Use of a bottom wire is necessary only for young vines (Fig. 4).

During the first year, shoots should be separated carefully and placed vertically downward from the top wire. The first positioning should be carried out as soon as the shoots have toughened after bloom which is usually two to three weeks after peak bloom (Fig. 5). Peak bloom is when 50 per cent of the flowers are open. The fused petals (the calyptra) fall off exposing the rest of the flower parts. A second positioning operation should be done about one month after the first. Extreme care must be exercised during the shoot positioning, as any shoot lost at this time may result in a poorly-filled trellis. Also, shoots broken off at this time may impair production for several years.

During the second year and thereafter, leave up to five buds on each spur along the arms of the vine for fruiting purposes. The total number of buds should be adjusted in accordance with the vigor of the vine, as explained.

Fertilization

The fertilization of grapevines in Pennsylvania is centered at present around four elements—nitrogen (N), potassium (K), magnesium (Mg), and manganese (Mn).

Identification of a nutritional problem is determined best by plant tissue analysis. The tests are made at The Pennsylvania State University laboratories on receipt of a special kit of samples and information from the grower. These kits may be purchased from the Agricultural Extension Office located in each county. Soil analysis is included with the plant analysis kit. Plant analysis is used also to monitor the nutritional status of a particular vineyard as well as for problem solving.

Fig. 4. Grapevine trained and pruned to the Single Curtain Cordon (No-Tie) System.

Nitrogen applications vary from nothing to two pounds per 1000 sq. ft. The amount to apply may be determined by the amount of growth, provided the vines were not seriously under- or overcropped. The application should be made in early spring before turning under the cover crop. When high rates of nitrogen are necessary, a split application is preferred. Usually one-half the total desired is applied in early spring and the remainder shortly after bloom. Another approach would be to apply one-half the desired amount in autumn after harvest (late November or early December) and the remainder in early spring. The most commonly used carriers are urea (46% N), ammonium nitrate (33.5% N), sodium nitrate (16% N), and complete-analysis fertilizers. Ammonium sulfate (20.5% N) is recommended when soil are of high pH or when iron and manganese deficiency symptoms are evident. Normal pH is approximately 5 to 6.

Potassium ("potash") deficiency may occur in soils of high pH, soils high in magnesium, or soils low in potash. Correction is accomplished by the application of potash in the range of two and one-half to ten pounds per 1000 sq. ft. Response is quickest when the potash carrier is applied in a two-foot band along each side of the plant. Potash may be applied at any time during the growing season. Three types of potassium carriers are available—muriate of potash

(60% K), potassium sulfate (50% K), and potassium nitrate (13-0-44). Muriate of potash is not recommended if the application rate required is over five pounds of potash per 1000 sq. ft.

Magnesium deficiency frequently occurs when the soil pH and soil magnesium are low and when soil potassium is high. Therefore, the usual correction procedure for this disorder is to broadcast dolomitie limestone at the rate of 50 pounds per 1000 sq. ft. If soil potassium is adequate, potassium fertilizer should not be applied. When the soil pH is higher than desired, magnesium should be applied in some form other than lime. Some common carriers of magnesium other than lime are hydrated magnesium sulfate (Epsom salts, 11% Mg), "Sulpo-Mag" (11% Mg), "Promesium" (22% Mg), and "k-Mag" (11% Mg). Apply these materials at the rate of five to six pounds of actual magnesium per 1000 sq. ft. Magnesium may be applied at any time during the growing season.

Manganese deficiency may be evident when plants are grown in soils with high pH values. Several approaches to corrections are available: application of manganese sulfate at the rate of five to ten pounds per 1000 sq. ft., application of potash at the rate of five pounds of potash per 1000 sq. ft., and use of ammonium sulfate as the nitrogen. Manganese and potassium carriers may be applied at any time during the growing season. Ammonium sulfate, on the other hand, should be applied in early spring.

Other Cultural Practices

Cover crops are used by commercial growers for several reasons: to provide competition for water and mineral elements in the late season which will help to mature the crop and wood for the dormant season, to help prevent loss of soil through erosion, and to reduce water runoff in early spring. A permanent cover can be used to advantage in reducing vigor of over-vigorous vines which do not produce a crop.

Common types of covers used are rye, rye grass, wheat, and barley which are not easily killed by frost. Rye, wheat, and barley usually are sown at the rate of two and one-half to three pounds per 1000 sq. ft., whereas domestic rye grass can be sown at the rate of one-third to one-half pound per 1000 sq. ft.

The time of seeding will vary from mid-July to early August. If rains are common during late July and August, the eover erop should be seeded at the earlier date. Application of four to six pounds per 1000 sq. ft. of a 5-10-10 analysis fertilizer also should be made before seeding the cover crop.

Crop control other than through balanced pruning is accomplished by flower cluster removal and berry thinning. Flower cluster thinning is the removal of entire clusters from shoots. Severity of cluster thinning is dependent upon the variety involved, vine vigor, and size of the crop. This technique is more important with *vinifera* and French-American hybrid

Fig. 5. A cluster of 'Concord' grape flowers just starting to expand.

varieties than with American varieties, as many of the French-American and *vinifera* varieties tend to overbear. Cluster removal with American varieties is usually limited to those instances when fruit production per shoot is excessive.

Young vines (up to three years) should have all clusters removed in order to enable proper development and training of the vine. Usually in the third year, one cluster is left on each shoot. After the third year some varieties may not need to be thinned, whereas other varieties always will need to be cluster-thinned to some degree. At present the general recommendation is to leave no more than two clusters per shoot for those French-American varieties

that need to be thinned. *Vinifera* varieties will survive better if cluster-thinned to one cluster per shoot. Cluster thinning should be done no later than one week before full bloom to obtain optimum response; therefore, careful note should be made of when the petal caps begin to fall off.

Berry thinning is the removal of the bottom one-fourth to one-third of each cluster, a practice beneficial to some table varieties—seedless and seeded. For example, 'Himrod', a seedless variety, and 'Buffalo', a seeded variety, benefit from the practice of berry thinning. Removal should be shortly after bloom. If properly done, berry thinning should result in well-filled, attractive clusters. When properly performed, cluster and berry thinning should improve fruit quality, wood maturity, and vine strength.

Insect and disease control are best accomplished by strictly following the recommendations available from County Agricultural Agents. These are based on the scientific work of professional plant pathologists, entomologists, and viticulturists, all specifically involved with the king of vines, the grape.

Harvest time will vary from area to area in Pennsylvania. The time to harvest depends upon how these grapes are to be used. For juice purposes, 'Concord' grapes should have attained a minimum soluble solids content of 15%. Grapes to be used for dry table wine, on the other hand, should reach an optimum of 20-22% soluble solids. Dessert grapes in the East are usually harvested when the berries have developed acceptable color and flavor.

Suggested References

Banta, E. S., *et al.*, 1969. Grape growing. Ohio Agric. Ext. Bul. 509. 24 pp.

Haeseler, C. W., 1970. Climatic factors and the potential for wine-grape production in several areas of Pennsylvania. Pa. State Univ. Agric. Exp. Sta. Progress Report 303. 12 pp.

Hedick, U. P., 1908. The Grapes of New York. J. B. Lyon Co., Albany, N. Y. 564 pp.

Pennsylvania State University Agricultural Extension Seasonal Publications obtainable through the County Agricultural Extension Agents.

Shaulis, N. J., T. D. Jordan, and J. P. Tomkins, 1966. Cultural practices for New York vineyards. Cornell Ext. Bul. 805. 39 pp.

Winkler, A. J., 1962. General Viticulture. Univ. of Calif. Press, Berkeley, Calif. 633 pp.

Arboretum Activities

The extensive dredging of the Swan Pond has been completed. This has enabled us to arrange for new plantings of *Rhododendron* (including choice cultivars donated by Mr. A. S. Martin), *Conradina*, and other taxa in the area. Soil removed has provided needed fill in the Medicinal Garden and other places. Recent removal of overgrowth in the Medicinal Garden has provided a much improved view of our colony of *Metasequoia*.

Representatives of new or choice cultivars have been transferred from our nursery to various permanent locations. These have included the Heath Garden where overly dominant junipers are being replaced by smaller conifers of suitable texture.

During the late autumn and early winter, there will be construction of a sanitary sewer connection by Springfield Township along Wissahickon Creek within the Arboretum grounds.

It is with considerable regret that we note the passing of Carl W. Fenninger and Richard B. Chillas, Jr. Both Mr. Fenninger and Mr. Chillas served for a number of years on the original Advisory Council of the Morris Arboretum.

Dr. H. L. Li attended the 8th meeting of the Academia Sinica, at Taipai, Taiwan on July 26-27. After the conference, he visited the Department of Botany and the Herbarium of the National Taiwan University and the Department of Biology of Chung Chi College, The Chinese University of Hong Kong. For the fall semester he is teaching the course "Plants and Human Culture," offered for the first time at the Department of Biology.

New work in the mycology laboratory is on the growth of *Pleurotus* spp. on wood from elms killed by the Dutch Elm Disease, *Dr. Allison* reports.

Mr. Angus Heeps provided two lectures to members of the Pennsylvania Horticultural Society "Garden Workshop," one on propagation and another on "Planning for Spring."

At the opening meeting of the current lecture series of the Torrey Botanical Club at the New York Botanical Garden, *Dr. Dahl* spoke on "Wall Structure and Composition of Pollen." He recently lectured on palynology in the Department of Geology. In response to two invitations to continue his researches on pollen in Scandinavia, Dr. Dahl will be on sabbatical leave during 1971.

Mr. Bruce Keyser recently accepted a full-time teaching appointment at Eastern Montgomery County Technical School. We wish him all success.

We are pleased to report that *Mr. John Irion*, formerly of Vick's Wild Gardens, Inc., has joined our gardening staff.

A. Orville Dahl

Cytology of Magnolia Hybrids. III. Intra-sectional Hybrids.

Frank S. Santamour, Jr.

In the first two papers in this series (Santamour, 1969, 1970), the hybrids investigated represented crosses between species belonging to different sections of the genus. The present study deals with hybrids between species belonging to the same section. Cytological techniques and methods were the same as those described previously.

Of the hybrids discussed in this paper, *M.* x *loebneri* Kache and *M.* x *veitchii* Bean were also studied by Janaki Ammal (1953). She gave chromosome counts on these hybrids but no details of meiosis or pollen fertility.

Buergeria Hybrids

The section Buergeria contains about 5 species, 3 of which are commonly grown in temperate climates. Among these species, all hybrid combinations are probably possible. The three most common species, of Japanese origin, are *M. stellata* (Sieb. & Zucc.) Maxim., *M. kobus* DC., and *M. salicifolia* (Sieb. & Zucc.) Maxim.. These species are all diploids with 2n=38 chromosomes.

The hybrid *M.* x *loebneri* was named in Germany in 1920, based on a presumed man-made hybrid between *M. stellata* x *kobus* that produced its first flowers in 1917 (Kache, 1920). Hybrids between these two species are common among open-pollinated populations in gardens in the eastern United States. The cultivar 'Merrill' resulted from a controlled cross of *stellata* x *kobus* made at the Arnold Arboretum in 1939 (Wyman, 1952).

Both 'Merrill' and an unnamed natural hybrid at the National Arboretum were examined cytologically. The pollen of 'Merrill' averaged 38.4 μ in diameter, and the other hybrid produced pollen with an average diameter of 40.4 μ. However, pollen abortion in these hybrids was 16% and 17% respectively! Such a high degree of pollen abortion was not expected in fertile diploid hybrids between closely related species.

Cytological study of specimens of the parent species provided some data relative to the high pollen abortion in the hybrids. Whereas an individual of *M. stellata* produced grains averaging 37.6 μ and 6% abortion, a plant of *M. kobus* had 23% pollen abortion and a grain size of 39.1 μ. Thus, pollen abortion in an individual of one of the parental species was higher than that in the hybrids.

No abnormalities of meiosis were noted in either the "parents" or the hybrids, and 19 bivalents were normally formed at metaphase I (Fig. 1a). All trees produced a good crop of fertile seed to open pollination. Therefore, it would appear that the relatively high pollen abortion of the hybrid is not related to large genomic differences between the parent species. Rather, the abortion is probably caused by small structural or genic differences, and may, in addition, be influenced by environmental conditions.

The hybrid *M.* x *proctoriana* Rehd. was named in 1939, and was based on a natural hybrid between *M. salicifolia* and *M. stellata* that had originated in Massachusetts in 1928 (Rehder, 1939). A single unnamed cultivar of this combination, which exhibited the characteristic anise leaf odor of the female parent, was examined cytologically. Pairing at metaphase I was regular, with 19 bivalents being formed. Pollen abortion was only 7% and the grains averaged 36.9 μ in diameter. Thus, cytological data support the close relationship between the two species.

Tulipastrum Hybrids

The cross between *M. cordata* Michx. and *M. acuminata* L. was made in 1943 at the U.S. National Arboretum by Oliver M. Freeman (Freeman, 1951). Both species are tetraploid (2n=76), and are the only American species of section Tulipastrum. In fact, many authorities believe that *M. cordata* should be considered a variety or subspecies of *M. acuminata*.

Two hybrids at the National Arboretum were examined cytologically and were tetraploids with normal meiosis. Pairing was invariably 38 bivalents (Fig. 1b). Pollen abortion in the hybrids was 10% and the grains averaged 46.8 μ in diameter. Pollen abortion in *M. acuminata* and *M. cordata* was 15% and 10%, respectively, with average diameters of 44.1 μ and 43.0 μ. No significance can be attached to the variation in pollen abortion or pollen size.

High pollen fertility and complete bivalent formation at meiosis in the hybrids indicate that the two species are closely related, but not necessarily varieties of the same species.

M. x *veitchii*, the oldest man-made hybrid in the genus *Magnolia*, is a cross between *M. denudata* Desr. (as female) and *M. campbellii* Hook. f. & Thoms., both of the section Yulania. According to Bean (1921), the cross was made in 1907 by Mr. Peter C. M. Veitch at the Royal Nurseries in Exeter, England. Five plants were raised from this cross, and the first flowering was in 1917. Four of the plants bore creamy-white flowers like the female parent, and only one showed the pinkish coloration of the male. This is the plant named *M.* x *veitchii* by Bean. It is a clone and should be so designated, since the name *veitchii* will also find correct application to all future products of the same cross.

Some variation in petal color of a clone may be expected as a result of climatic and edaphic conditions or rootstock effects. Thus the color differences among individuals of *M.* x *veitchii*, growing in different localities, may be caused by environmental or cultural factors. It is also possible that some plants resulting from open-pollinated seed of *M.* x *veitchii* have been labelled with the female parent's name. The true parentage of such plants may be difficult to determine, except after many years of observation.

Both parent species are hexaploid (2n=114) and so is the hybrid. Chromosome pairing at metaphase I regularly showed 57 bivalents (Fig. 1c) and pollen fertility was 98%. Average pollen grain diameter of the hybrid was 42.5 μ, as compared to 42.8 μ for *M. denudata*. Observations on the chromosomes and pollen thus indicate a close phylogenetic relationship between the two parental species.

Fig. 1. Metaphase I in (a) *M.* x *loebneri*, (b) *M. cordata* x *acuminata*, and (c) *M.* x *veitchii*. Some separation of bivalents has taken place in (b) and (c). 530x.

Literature Cited

Bean, W. J. 1921. *Magnolia Veitchii. In* P. C. M. Veitch, J. Roy. Hort. Soc. 46:321.

Freeman, Oliver, M. 1951. *New Magnolia* hybrids. Nat. Hor. Mag. 30:132-135.

Janaki Ammal, E. K. 1953. The race history of magnolias. Indian Jour. Genet. Pl. Breed. 12:82-92.

Kache, Paul. 1920. Schönste Blütensträucher des April. Gartenschönheit 1:18-20.

Rehder, Alfred. 1939. New species, varieties, and combinations from the collections of the Arnold Arboretum. Jour. Arn. Arb. 20:409-431.

Santamour, Frank S., Jr. 1969. Cytology of *Magnolia* hybrids. I. Morris Arb. Bull. 20:63-65.

Santamour, Frank S., Jr. 1970. Cytology of *Magnolia* hybrids. II. *M.* x *soulangiana* hybrids. Morris Arb. Bull. 21:58-61.

Wyman, Donald. 1952. Spring comes to the Arnold Arboretum. Arnoldia 12:45-46.

Laura L. Barnes Lecture

The Barnes Lecture for 1970, one of a series generously established in 1963 by a group of students and alumni of the School of Botany and Horticulture of the Barnes Foundation in honor of Dr. Laura L. Barnes, was held on November 12. The distinguished lecturer was Dr. Rolla M. Tryon, Jr., Curator of Ferns, Gray Herbarium, Harvard University. The title of his stimulating lecture was "Ferns of the Andes and the Amazon."

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